June, 1977
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Mining the Asteroids

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Security for a Plutonium-Based World
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Technology Review

Edited at the Massachusetts Institute of Technology

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A computer that can see gets its first real job.

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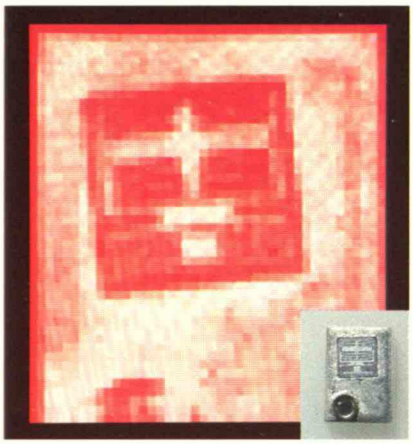

Digitized Image Actual Part

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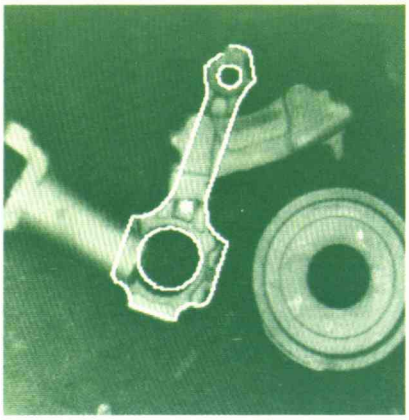
Under development at the Labs are more sophisticated computer vision systems. One of them not only sees, it also learns from what it sees.

To illustrate: Show the system a new object. A connecting rod, say. It analyzes the part, computes its geometric properties, forms a model, and commits this model to memory.



It then has the knowledge to recognize similar connecting rods.

Moreover, the system has specially developed programming that allows it to locate a rod amidst a collection of different parts...even if the rod is poorly lit, or only partly visible, or has a low-contrast background.

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General Motors Research Laboratories
Warren, Michigan 48090

Edited at the
Massachusetts Institute of Technology

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Technology Review

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Power and Proliferation

Colin Norman's column on nuclear proliferation (*"Toward a Non-Nuclear Future in a Nuclear World," October/November, 1976, pp. 8-9*) overlooks one basic fact: power reactors are the lousiest way in the world to produce weapons-grade plutonium. At current usage of nuclear fuel, almost 20 per cent of all plutonium produced in a power reactor is plutonium-240, which inhibits an explosive chain reaction by spontaneous fission, which causes premature ignition and fizzle. The discovery of this isotope nearly doomed the World War II project to build a plutonium weapon.

Relatively pure plutonium-239 is needed to build a working weapon. Since the Pu-240 cannot be separated from Pu-239 by chemical means, there are two methods to obtain this plutonium: remove fuel rods from a reactor very early, before the Pu-240 forms (this is readily detectable under I.A.E.A. monitoring); or build a production reactor using natural uranium and graphite or heavy water (which is apparently the route India took).

Thus, power reactors can be divorced from the problem of proliferation. Reprocessing and enrichment technology is a separate case. I must also disagree with Mr. Norman's assumption that if the U.S. would forego nuclear exports and plutonium recycle, we would influence other European nations to do the same. The rest of the world clearly does not follow the moral leadership of the U.S. Western European nations will do what they see as necessary for themselves and their economies, as sovereign nations do, and should do.

Jack Penkrot
Pittsburgh, Penn.

Mr. Norman replies:

I simply refer the reader to "Plutonium, Proliferation, and Policy" by Victor Gilinsky *(February, 1977, pp. 58-65)* for an informed rebuttal to Mr. Penkrot's thesis that power reactors are not adequate sources for weapons-grade plutonium. As for the moral leadership of the U.S., I believe it would be profoundly immoral for this country not to try to curb the proliferation of nuclear weapons by any diplomatic means available.

Belief and Objectivity

Martin Gardner has not only conveyed but exemplified the frightening influence that belief can exert upon objectivity.

Mark G. Shafer
Irvine, Calif.

Dr. Shafer is affiliated with the School of Social Sciences of the University of California at Irvine. — Ed.

I am indebted to Martin Gardner, (*"Magic and Paraphysics," June, 1976, pp. 42-51*) for his debunking of the paraphysicists. One might well suppose, as the Amazing Randi suggests, that any intelligent person looking into the situation would arrive at the same conclusions, but this does not allow for the naïveté of many intelligent people, scientists among them. Indeed, an article in the very same issue as Mr. Gardner's expose displays a budding para-astronomy (*"On Hands and Knees in Search of Elysium," pp. 22-29*).

Frank Drake's suggestion that immortality may be common seems to be untestable; his belief that it will be possible to transfer the memory of one brain to another reveals a lack of appreciation for the brain's complexity and the state of scientific knowledge. His further conclusion that "most intelligent civilizations become immortal" and that "it is likely that immortals will dominate space" defies all logic. This sort of reasoning seems more appropriate to science fiction or the "Tonight" show than the *Review*. It distresses me that M.I.T. should be associated with this pseudo-science. I find Uri Geller's exploits more plausible.

Elliot M. Cramer
Chapel Hill, N.C.

Dr. Cramer is Professor of Psychology at the University of North Carolina. — Ed.

Dr. Drake replies:

I do not agree that the search for extraterrestrial life is a para-science. Science works by making predictions on the basis of existing knowledge and theories as to what a feasible experiment might reveal. All serious discussions of extraterrestrial life to date have been exactly in this vein: building on existing scientific knowledge to establish those experiments most likely to make progress on the subject. Nothing is asserted as fact which has not been firmly established — the distinction, of course, which separates true science from parascience.

One's first reaction to the idea of immortality is to rebel against it. But once one has thought about it, the idea is neither bizarre nor "impossible." Obviously there is something biochemical or biological that leads to eventual deterioriation, aging, and death of organisms. In principle, at least, we can identify the process and, as in so many areas of medicine, find means to eliminate or reverse it. Even in the short interval since my article appeared in the *Review*, researchers at the University of Wisconsin have reported the identification of undesirable chemical bonds in DNA molecules. These bonds occur as an organism becomes older and result in the deleterious effects which we describe as aging. If the researchers' conclusions are correct, the way is open to develop processes to break these bonds and thus eliminate the aging process.

There are some theories of aging that attribute it to hormonal processes in the body. The primary example is the aging at breakneck speed that occurs in salmon after spawning. Recently, at least one similar fish, the steelhead trout. has been observed to degenerate, in the sense of apparent aging, and then regenerate, in some cases more than once in a single individual. This is a specific case where the aging process has reversed itself, providing evidence that the process exists and could well be available to human beings.

The existence of immortality is testable. All we have to do is to find some examples of "Them" out there and see where their own development has taken them.

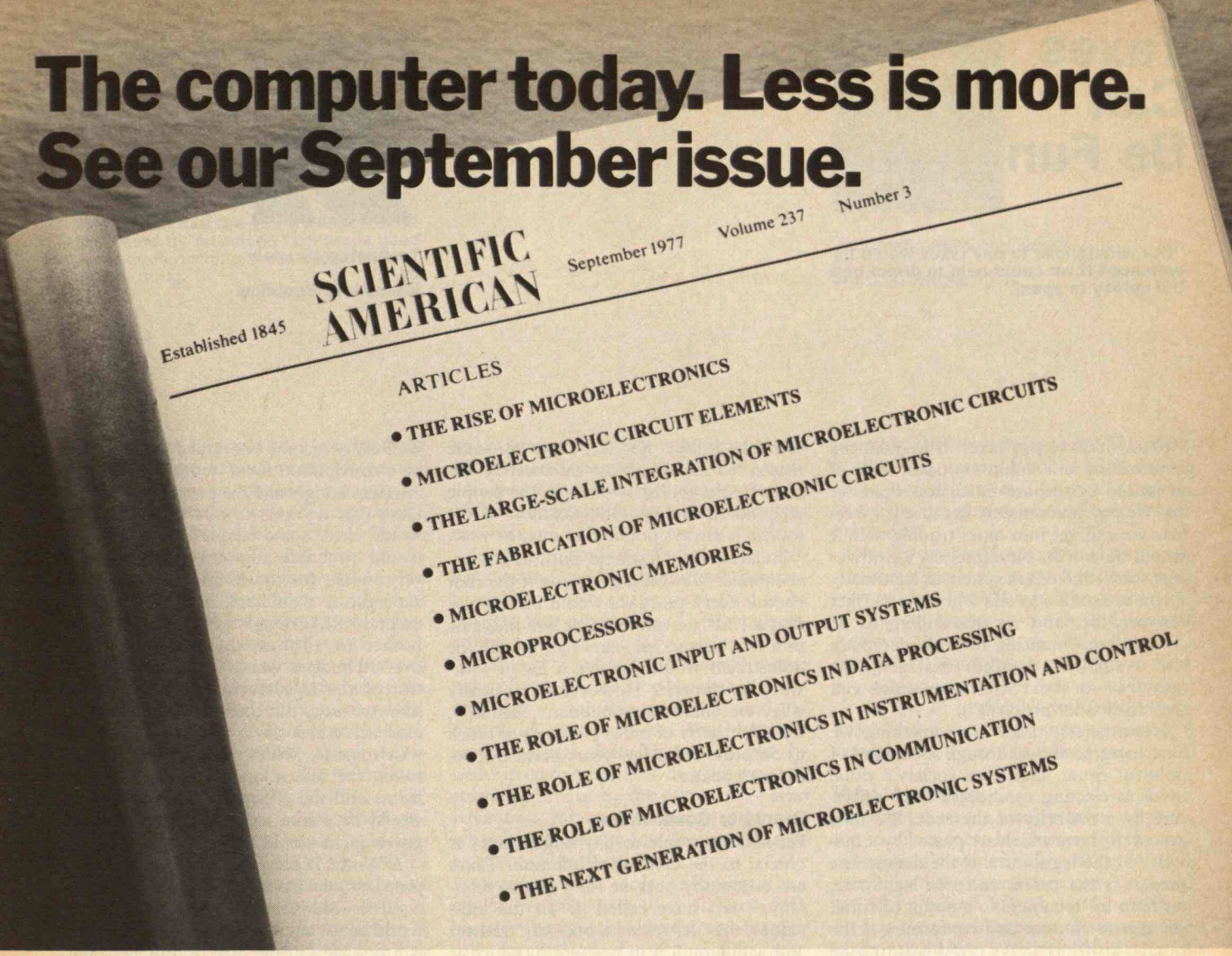
How Swedes Save Energy

"Energy Efficiency, European Style" *(October/November, 1976, p. 24)* reports our work comparing energy use in Sweden and the U.S. ("Efficient Energy Use, the Swedish Example," Lawrence Berkeley Laboratory Report LBL 4430, published in *Science* for December 3, 1976). The summary contains some inaccuracies.

First, as the data show, the private automobile — and not mass transportation, as you implied — is by far the most important travel mode in Sweden and Germany. Only in the most densely populated cities, where automobiles are most inefficient,

(Continued on p. 80)

The computer today. Less is more. See our September issue.



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Taxes Can Be Fun

"Our willingness to pay taxes would be enhanced if we could help to direct how the money is spent."

Technology/Society
by
Kenneth E. Boulding

Nobody likes to pay taxes. If we financed government on a voluntary basis, most of us would contribute much less than we do. We pay taxes mainly because if we refuse we will get into more trouble than it would be worth. Nevertheless, we all accept some kind of tax system as legitimate. There are public goods which no market can provide, and we are willing to be coerced into financing them if everybody else is similarly coerced (this being the only way to avoid what economists call the "freeloader problem").

Nevertheless, taxes are something we have to agree about through some kind of political ritual. Our own society's ritual involves electing candidates to a legislature by a majority of the vote. We then accept the laws which are passed by a majority of the legislature. If the democratic process is not perceived to be legitimate, we're in for trouble. No amount of ritual can assure consent and conformity if the ritual is disbelieved. We saw this during the war in Vietnam, where rising resistance and diminishing popularity of the war eventually removed the people responsible for it from power.

Inflation: A Sneaky Tax

Demand for public subsistence has been rising over the decades, at least in the minds of powerful political decisionmakers. As a result, the tax system is pushed to the limits of acceptability and legitimacy. The worldwide and almost universal phenomenon of inflation, even in the socialist countries with their strict controls, testifies to this proposition. Inflation is closely related to the inability of governments to raise taxes commensurate with their expenditures. In fact, inflation is a sneaky form of taxation which is accepted only because it is regarded as an act of nature rather than of government. This is an illusion that helps governments to get away with more spending than their citizens will readily accept. The burden of inflation on various groups in society is largely unknown, which again perhaps explains why we tolerate it. We do not know whose private welfare is diminished by the absorption of resources into government and the production of presumably public goods. There is some reason to suppose that inflation is felt most by the foolish — that is, the people who hoard money. And taxation of the foolish is always popular among the wise.

Inflation is unaesthetic, but it is not uneconomic. We could get along if the foot shrank every year; we would understand that a 12-ft. person this year was the same as a 6-ft. person ten years ago, though the adjustment would involve a lot of awkward arithmetic. However intrinsically silly, we could accommodate. Similarly, it's silly that $1 of today buys only as much as 50 cents did a few years back. But we accommodate.

Grants to Government

Persuading people to pay higher taxes is crucial to the control of inflation. Taxes are essentially part of the "grants economy," as I have called it. To the individual, they represent a one-way transfer and a diminution in net worth, which is the ultimate definition of a grant. What we get for our taxes is merely a license to live in our society. It is absurd to suppose that we get anything more specific; it is the essential property of public goods to be unspecific.

Willingness to make voluntary grants, however, is closely related to our identification with the object of the grant. We make large grants within the family, something like 30 per cent of GNP, because people identify with their children, their spouses, or even their parents and grandparents. We give smaller grants to causes with which we identify and to organizations that contribute to our identity, such as the church. We do not give grants voluntarily to people we know nothing about or for objects with which we do not identify. Even though we do not pay taxes voluntarily, our willingness to pay taxes — our perception of them as legitimate — depends on our identification with the object, just as it does in voluntary contributions. The more uncertain the object, the less will be our willingness to shell out for it.

Our willingness to pay taxes would be enhanced if we could help to direct how the money is spent. I suggest, therefore, that with every income tax return there should be a distribution form itemizing the government budget and the proportion of our taxes that we wish to allot to each. This would cheer some people enormously. It would probably not affect government very much, for the ultimate decision on expenditure would still rest with government itself. Enough people would not bother to allocate their taxes so that over-all budgets would remain under control of the legislature and President, as they are now. But there would be annual feedback which the government would be wise to note. Widespread differences between the allocations on the taxpayers' forms and the allocations on the budget would be a sure sign of trouble. A wise government would adjust accordingly.

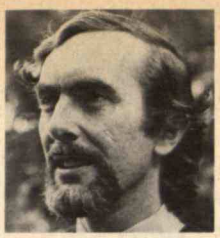
A World Peace Tax Fund is being proposed by which a taxpayer would allocate a portion of his taxes to a special fund for world peace and away from defense. That is a first step in the direction of personal tax allocations, and seems to me sound. I hope it will mark the beginning of a closer relationship between the preferences of the taxpayer and the policies of government.

Voting should not be the only response of the citizen to government policies. Personal tax allocation would challenge but not undermine the essential authority of government; I suspect it would even enhance the government's authority. It would certainly make paying taxes a lot more fun.

Kenneth E. Boulding is a director of the Institute of Behavioral Science and Professor of Economics of the University of Colorado at Boulder. He writes regularly for the Review.

You Are What You Eat

"More than half the energy and protein harvested by American farmers is used to produce nothing more useful than animal dung."



Technology/Environment
by
Ian C. T. Nisbet

The food we buy can have a substantial impact on the environment. Of course, consumers' choice depends strongly on the relative prices of food items in the marketplace. And it has to be recognized that the market for food is substantially distorted by government intervention. The government subsidizes some products at the expense of others, and it sets standards for quality, safety, and appearance which limit the availability of some items and raise the prices of others. Nevertheless, the customer makes the ultimate decisions. Every time we pick an item from the market shelf, we contribute to patterns of consumption which help to determine land use, pollution, and public health.

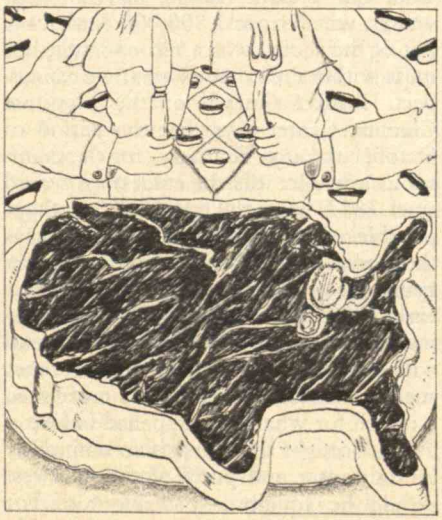
Eating meat has the most critical environmental impact. Despite selective breeding, domestic animals are still inefficient machines for converting solar energy into food. It takes roughly 6 lbs. of feed to produce 1 lb. of chicken meat, 8 lbs. to produce 1 lb. of pork, and 16 lbs. to produce 1 lb. of beef. Since almost all farm animals in the U.S. are fattened on prepared feed, the steadily rising demand for meat fosters a disproportionate demand for feed grains. On a *per capita* basis, the U.S. uses more than twice as much grain as the world average, but fully two-thirds of this is consumed indirectly, as meat. So more than half the energy and protein harvested by American farmers is used to produce nothing more useful than animal dung.

More Is Less

The environmental consequences of raising cattle are manifold. U.S. agriculture is energy intensive. It now takes about a quarter of a gallon of gasoline to produce a bushel of feed corn. Under feedlot conditions, about 78 joules of fossil energy are consumed to produce one joule of food energy in the form of beef. Most of the energy is used to fix nitrogen for fertilizers. Yet nitrates from heavily fertilized fields and from feedlots are severely polluting ground water. More serious, the worldwide fixation of nitrogen for fertilizers is now a significant fraction of the global nitrogen cycle. Nitrous oxide produced by denitrification of nitrates in the soil is now recognized as a threat to the stratospheric ozone layer, probably comparable in magnitude to that posed by fluorocarbons and much more difficult to control.

Impacts on land-use are also severe. Rising demand for beef stimulates demand for grains, which causes more land to be brought into production. This usually involves lands of marginal value, whose cultivation results in disproportionate risks of soil erosion, further demands for drainage of valuable wetlands, and expensive irrigation projects. Apart from the environmental destruction wrought by many irrigation projects, they are typically subsidized twice by the taxpayer — who pays first for construction, and again when unrealistically low fees are charged to farmers for water.

Of course, most cattle feed on grain and alfalfa for only part of their lives. Still, much of the western United States is tragically overgrazed. Eastern visitors who admire the wildness of the deserts seldom appreciate that they are largely man-made, and that many areas now covered in mesquite or cactus once supported rich grassland. This overgrazing is perpetuated by the U.S. Forest Service and Bureau of Land Management, which permit too high densities of cattle and sheep and charge unrealistically low grazing fees. The result is that vast areas of public land in the West are effectively private ranches, closed to the public who subsidize their destruction.



Drawing: Maira Berman

Nor is the problem confined to North America. The U.S. demand for beef is at least partly responsible for the destruction of tropical forests in South and Central America. And in both continents, attempts are being made to increase meat production with the "chemical plow" — the use of herbicides to destroy sagebrush and woody vegetation in the hope that grass will grow in their place.

Meat Machismo

Although there are many reasons why eating so much meat is environmentally and economically undesirable, the individual consumer has other, more direct reasons for eating less of it. I drastically cut back on my own consumption of meat a few years ago, when I learned the extent of contamination of the U.S. food supply by potentially carcinogenic chemicals, which are concentrated in animal fats. The chemicals of greatest concern are residues of soil insecticides (dieldrin, heptachlor, chlordane, etc.) which are used on corn and enter the food supply via feed crops grown in the same soil. Other carcinogenic residues of insecticides are also concentrated in animal fat. And I am concerned about residues of synthetic hormones such as diethylstilbestrol (DES), used to promote weight gain in cattle, and about the presence of significant quantities of dioxins (toxic contaminants of range herbicides).

True, the threat to health posed by these residues is somewhat speculative. Certainly one would not expect effects of these relatively new chemicals to show up yet in the cancer statistics, because of the long latent periods for chemically-induced cancer. But disturbing new evidence indicates an association between present patterns of cancer incidence and consumption of meat. It has long been known that cancer mortality is associated with affluence, and specifically with "western" diets — high in animal fat and low in

(Continued on p. 16)

Bread and Water

"The United States seems headed for what could be the worst weather disaster in its history."

Science Report by Robert C. Cowen

In New England, a tough winter has given way to summer breezes and thriving gardens. Farther west, in America's bread basket, winter wheat once threatened by drought has revived under March rain and snow. And even in California where drought has forced sporadic water rationing, Gordon Snow, Special Assistant to the Director of the California Department of Food and Agriculture, is saying that farmers won't suffer so much after all because 8,000 new wells will be drilled this year.

Thus it is that the United States seems headed for what could be the worst weather disaster in its history. With winter gone, we're becoming complacent once again. And that, according to Robert D. Miewald of the University of Nebraska, could be tragic for a country that lacks the reserves of energy, food, and water to stand up to prolonged bad weather.

A political scientist, Dr. Miewald looks at weather in terms of people rather than climatic statistics. He told a symposium on drought at the annual meeting of the American Association for the Advancement of Science in February that extreme weather should be considered a "social natural event." By that he meant an event whose impact depends on how well people are prepared to cope with it.

"Do we regard drought as just an unpleasant event in an otherwise happy and pleasant world?," he asked. "If we just regard drought as so many 'bad years' to be endured, that may be its worst impact of all." Impose a little rationing, sink more wells, appeal for emergency aid — such measures can tide a region over, Dr. Miewald said. Meanwhile, the real problem — too many people trying to live beyond the carrying capacity of the land — continues to intensify. This kind of approach, he said, will make the problem of drought itself ultimately unsolvable.

Forecast: Extremely Normal

What Dr. Miewald says about drought applies to all forms of extreme weather. Meteorologists can't agree on the direction the climate is taking, if indeed it is changing in any consistent way at all. But they are virtually unanimous in warning that the United States, and the world, have lost resiliency to cope with what should be expectable extremes of our present "normal" climate.

"You don't have to argue that the climate's getting worse; we are becoming more vulnerable to it as it is," says Don Gilman, Chief of the U.S. National Weather Service's long-range forecasting group. And dismissing current scare stories about an impending ice age or other major climatic change, the World Meteorological Organization says any such trend "is likely to be gradual and would be almost imperceptible." However, it warns in an official statement, "The natural shorter-term variability of climate is becoming increasingly important as the result of growing pressure on natural resources. It is this variability which has been highlighted by the disastrous droughts and weather extremes in many parts of the world. In view of the increasing importance of climate to many human activities, greater use should be made of existing knowledge of this variability in planning for economic and social development."

Sunspots and Drought

Indeed, you don't have to freeze in an ice age or roast in the heat of a run-away carbon dioxide greenhouse to appreciate what our present climate can do. Last winter, which froze 1,800,000 Americans out of their jobs, was a record-setter, but quite within the range of what we can expect. Robert Quayle of the National Climatic Center says that the period of October through February, for the country as a whole, was the coldest on record since 1887, when the first reliable and applicable records were available. He says the season probably is in the running for being one of the coldest going back to the early 1800s. However, he adds, emphasizing that one has to take anecdotal material with caution, stories from earlier times suggest that the season was no more than a match for what has happened before.

The drought that persists so ominously in California and parts of the Midwest should be equally expectable too. For years, a handful of experts, notably Walter Orr Roberts working at the National Center for Atmospheric Research (N.C.A.R.), have urged the validity of a correlation between the 22-year (rather than the 11-year) sunspot cycles and recurring Midwestern drought. That correlation predicts return of what could be dust bowl conditions right about now.

Without clear explanations of how minor fluctuations in the energy output of the sun could influence earth's weather, most meteorologists consider sunspot correlations wishful thinking. As a graduate of M.I.T.'s Department of Meteorology, drilled in the hazards of matching up numbers that have no intrinsic relationship, I have thought this skepticism justified. But now my equally well-drilled fellow alumnus J. Murray Mitchell, Jr., Senior Research Climatologist at the Environmental Data Service says, "I'm falling off the fence on the side of sunspots." So it's time to think again.

Dr. Mitchell was persuaded to the theory by data going back to 1700 which Charles W. Stockton of the University of Arizona produced from tree rings. "Don't ask me to explain it," Dr. Mitchell says. "I can't. But the phase-locking between drought and the sunspot cycle is strong." He adds that his study was submitted to independent statistical analysis to "make sure we weren't doing something slippery with the data." In statisticians' terms, the drought cycle revealed by the data is judged to be real at a 95-per-cent level of significance, while its correlation with the sunspots is judged meaningful at a significance level of 99 per cent. In other words, the statisticians believe there is respectively only 5 per cent probability and 1 per cent probability that the cycle and the correlation are mere chance appearances in the data.

Dr. Mitchell insists that the correlation does not explain climatic behavior. He told a symposium at the University of North Carolina two years ago:

"Since we do not yet have a good grasp of all causative mechanisms, and we are not yet certain what constitutes a suitable general physical framework to encompass those mechanisms, it is rather absurd for us to speak of having 'explained' [climatic

Illustration: Judy Richland

changes]." He continued, "Where interesting statistical relationships appear to exist, as between climatic variations and such plausible forcing phenomena as volcanic eruptions, carbon dioxide trends, or sunspot numbers, these should by all means be reported as possible clues to climatic behavior. . . . But let them be recognized for what they are: statistical relationships and hypotheses. And let them be recognized also for what they clearly are not: self-sufficient explanations of climatic behavior and reliable bases for climate prediction."

Nevertheless, recurring midwestern droughts do show up in the tree ring data. And the correlation with the sunspots is pronounced. This should at least alert us to the possibility of a period of drought. Thus Dr. Mitchell says, "I'm not predicting drought will occur this summer. I am warning that this analysis suggests that, right now, we should be extra cautious."

The Genesis Strategy

Steven Schneider, climatologist at N.C.A.R., says it is abundantly clear that extreme weather, including midwestern drought, can and likely will occur. Under the circumstances, he adds, it is foolish not to anticipate bad weather, instead of letting such basics as food reserves drop so low they could not make up for even the immediate impact of severe drought in American wheat lands.

With Dr. Miewald, Dr. Schneider stresses the point that weather disasters are partly manmade through lack of planning. He urges what he calls a "Genesis strategy" of building up large grain reserves, a strategy named for the Biblical Joseph who garnered reserves from Egypt's seven fat years to feed the country during seven lean years. The trouble is, this apparently sensible strategy runs afoul of the fact that we have organized our affairs as though weather extremes didn't matter. The result, says Wayne Decker of the University of Missouri, is that the economy, at this point, can't accommodate the Biblical precedent.

Dr. Decker, who headed a National Research Council (National Academy of Sciences) study of climate and food, explains: "Weather fluctuations produce more grain than growers can sell in the best producing areas, then bad years create deficits. So the national planner has to find ways to even things out through a national storage policy. That sounds easy. But the economic disincentives against storing grain that come out of the pricing structure are powerful, complex, and are not going to be solved overnight."

At this writing, the paramount national concern is energy, not weather. Yet the two subjects are equally important, and complex. In fact, they are interrelated since mining western coal depends on scarce water and farming depends on increasingly scarce energy. The challenge derives from the fact that the United States has evolved a way of life that is dangerously incompatible with reality. We're due for a long, sometimes agonizing, and intricate adjustment.

Dr. Miewald speaks of overpopulation in the semi-arid West. How is the country to halt, or even reverse, the growth of its sun belt? Last year, the American Meteorological Society warned that complacency about hurricanes has encouraged the buildup of vulnerable communities on the East Coast to the point where major hurricane disaster threatens. True, but these communities can't just be bulldozed away. The A.M.S. suggests no such draconian measure. It does urge new zoning laws to restrict development and contingency planning on a community-by-community basis. But that will take years of local politicking, trade-offs, and expense.

Acknowledging the horrifying complexity of the challenge, Wayne Decker notes, "The Academy study made one point strongly. A few decades ago, weather-related disasters were regional and did not have such serious impact. Now, with today's population and development, we have reached a critical point. . . We are talking about tackling some very complex problems. They are not ones you're going to solve by act of Congress, so to speak. But they are problems that we can no longer neglect."

I hope someone in Washington, at least, is listening to the Academy message. Meanwhile, if any reader would like to learn more about the challenge we face, read Steven Schneider's book, *The Genesis Strategy* (Dell), recently issued in paperback. You don't have to agree with his solution. But his account of what we do and do not know about climate is reason enough not to take the "average" weather for granted.

Robert C. Cowen is Science Editor of the Christian Science Monitor *and a regular contributor to* Technology Review.

Discovering Earth's Secrets — For a Price

"Does basic research in the earth sciences have sufficiently high priority to join the big-science league?"

Washington Report by Colin Norman

Some spectacular theories and discoveries have transformed thinking about the earth's history. They provide a convincing explanation of the forces that push the continents around. But this new understanding inevitably prompts a series of intriguing new questions. To answer them, a group of geophysicists are now proposing a major research program that will cost several hundred million dollars over the next decade.

The proposal is being drafted by an international committee of distinguished earth scientists. It is expected to be considered by the National Science Foundation (N.S.F.) in the next few months. It will be interesting to watch the proposal's progress through the federal bureaucracy, for it contains some noteworthy features.

Aside from its projected cost — $400 million between now and 1987 — the proposed program is likely to involve several different countries. And it will entail the conversion into a deep sea drilling vessel of the *Glomar Explorer*, the ship used by the Central Intelligence Agency to salvage parts of a sunken Soviet submarine from the Pacific in 1974.

The program's warrant is the revolution in the earth sciences that began with publication in the mid-1960s of the theory of sea floor spreading, and continued with the theory's confirmation and extension. According to the theory, the continents were once part of a giant supercontinent which began to break up about 200 million years ago into land masses that continue to shift.

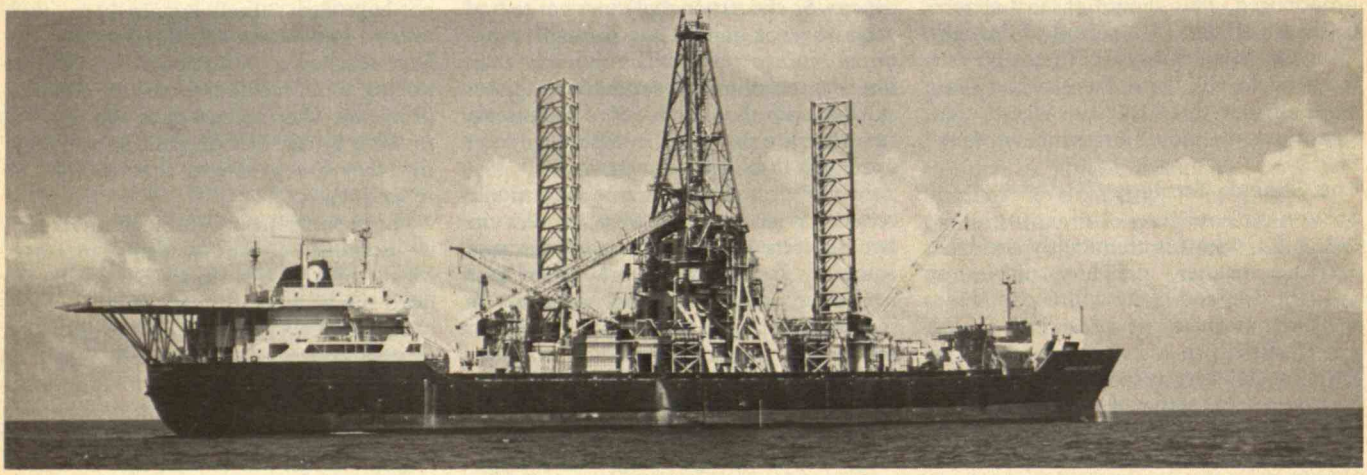
The driving force originates along the mid-ocean ridges, such as the mid-Atlantic ridge which runs for thousands of miles along the ocean floor between North and South America on one side and Europe and Africa on the other. New ocean floor is constantly generated along the ridge as molten lava rises from the earth's mantle and is pushed aside by newer lava. The process is thought to have begun within the supercontinent itself. It is generally acknowledged to be the cause of earthquakes and other geophysical phenomena along some of the margins where ocean crust and continental crust merge.

Convincing evidence to support the theory has come from a program known as the Deep Sea Drilling Project, begun in 1968. D.S.D.P. has drilled thousands of rock samples from the ocean floor using a specially constructed drilling vessel, the *Glomar Challenger*. Recently, D.S.D.P. was turned into an international effort, funded mostly by the U.S. (through N.S.F.), but with France, Germany, Britain, Japan, and the Soviet Union each contributing $1 million a year. D.S.D.P. is due to end in September, 1979, however, and so the proposed program is essentially designed as a follow-on.

Though the sea floor spreading theory has been confirmed — at least in its general outline — a number of puzzles remain. For example, our understanding of the processes occurring along the active oceanic-continental margins and in the deep ocean trenches remains sketchy. Further, it is reckoned that the continents themselves are about 3.5 billion years old, which means that they were probably joined together for more than 3 billion years.

Why did they part company when they did? And what effect has the slow march of the continents across the globe had on the earth's climate?

Answers to some of these questions may be found by drilling deep into the oceanic margins, into the ocean trenches, and into the ocean floor itself. But if we drill and strike oil and gas deposits along the margins, the consequence could be environmental disaster unless heavy, complex, blowout preventers are employed. Moreover, drilling into the ocean trenches



The Central Intelligence Agency used the *Glomar Explorer* to salvage parts of a sunken Soviet submarine from the Pacific in 1974. But soon it may be dredging up more benign secrets. Oceanographers are hoping that Congress will vote to convert the ship — now in mothballs — to a drilling vessel for deep-sea-floor exploration. The cost is estimated at $52 million, about half the cost of starting from scratch. (Photo: Global Marine, Inc.)

could involve drill strings far longer and heavier than any now in use. Thus the more interesting drill sites are beyond the reach of the *Glomar Challenger*, whose lifting capacity is limited.

Because the *Glomar Explorer* was built specifically to hoist large weights, earth scientists are eyeing it as a potential alternative. Last year, N.S.F. asked Global Marine, Inc., the company which built both the *Explorer* and the *Challenger*, to estimate the cost of converting the vessel. In April, the company reported to N.S.F. that it would cost about $52 million to convert the ship into a vessel capable of drilling virtually anywhere, a sum which is about half the cost of building a new drill ship. At present, the *Explorer* is in mothballs near San Francisco; although it belongs officially to the federal government, there is no other obvious use for it.

With this possibility in mind, a consortium of oceanographic institutes taking part in the D.S.D.P. established a committee last year (under the chairmanship of Manik Talwani, a geophysicist at the Lamont-Doherty Geological Observatory) to investigate the prospects for ocean drilling in the 1980s. That study resulted in the proposal for a $400 million, decade-long effort.

A draft report by the committee urges that there be no hiatus in ocean drilling when the present phase of the D.S.D.P. expires. It recommends that the *Glomar Challenger* be kept in operation until 1984, drilling in accessible sites — particularly in regions likely to yield information about the geology and chemistry of the ocean's evolution. In the meantime, the committee recommends that the *Glomar Explorer* be converted in time to start drilling in some of the more difficult sites by 1981.

The $400 million price tag will include the cost of preliminary site surveys and their analysis and interpretation — funds which the committee says should be specifically earmarked before the program proceeds. But the estimate does not include the projected cost of converting the *Explorer*.

The proposal will go to N.S.F. with the enthusiastic backing of most of the geophysics research community in the U.S. and with the endorsement of many distinguished earth scientists abroad. And it cannot hurt that President Carter's new science adviser is Frank Press, former head of the Earth and Planetary Sciences Department at M.I.T.

Nevertheless, there will be controversy over the large sum of money involved. Does basic research in the earth sciences have sufficiently high priority to join the big-science league?

If the answer is "yes," N.S.F. will probably seek international participation in the program. International cooperation would not only help reduce the total cost to the U.S., but would also help in selling

(Continued on p. 17)

Memories of a Whale

"Through our technology we have . . . substituted human myth for natural reality, and we wonder why things go wrong and why we starve for nourishment."

Special Report by Robert Finch

Around Thanksgiving, a dead 50-ft. finback whale washed up on Corporation Beach in Dennis, Mass., on Cape Cod. Since a whale doesn't beach in your backyard every day, the event attracted sizeable crowds, causing massive traffic jams on the narrow back roads and in the front yards of nearby property owners. On Saturday a team of scientists from the New England Aquarium came down to take tissue samples to determine the cause of death. On Sunday a six-inch hawser was looped around the whale's flukes and a Coast Guard cutter hauled the carcass off the beach and towed it toward a deep water dumping ground somewhere beyond Provincetown. In the two days that the whale's body lay on the beach, an estimated 5,000 persons, from on and off Cape Cod, came to view the whale.

Two weeks later, when I returned again to the spot, the only sign of anything unusual was the overclean beach. The tide had smoothed the sand and licked clean whatever vestiges of flesh had been left behind by the sanitary crews. The cold salt wind had lifted the last traces of that pervasive stench of decay that clung to our clothes for days, and now blew clean and sharp.

I was startled at how quickly we dispose of mortality. The roads to the beach had been cordoned and patrolled within hours of the whale's discovery; the marine mammologists had cut quickly and efficiently; and the refloating of the carcass, well co-ordinated with the tides, went off flawlessly. What had so manifestly occupied this space only a short while ago was now utterly gone.

And yet, the dead whale continued to lie heavily on my mind, like a persistent odor in the air. The whale's dark shape, though sunken now somewhere beneath the waves, still loomed before me. What was it, after all, that we had seen?

Like Children at a Zoo

Even the thousands of us who managed to reach the beach before it was closed off "for health reasons" did not see very much. Whales, dead or alive, are protected these days under the Federal Marine Mammals Act, so shortly after we arrived the local police stopped people from actually touching the whale. I could not regret this, since in the past beached whales, still living, had had cigarettes put out in their eyes and bits of their flesh hacked off with pocket knives by souvenir seekers.

And so, kept at a distance, we looked on while the white-coated, plastic-gloved specialists carved open the thick hide with meat knives and plumbed the depths of the whale's body for clues to its death. What were they pulling out? What mystery had they plucked from that huge mass of fetid flesh? We would have to trust the specialists for the answer.

As I remembered the ever-growing crowds, drawn like flies to carrion, the question seemed to be not why the whale died, but why we had come to see it. What magnetized the whale's bulk, drawing people from hundreds of miles away, clogging roads, spilling us over onto private lawns and fields? I watched as electricians and oil truck drivers pulled their vehicles off the roads and clambered down to the beach, abandoning their assignments. Women in high heels and pearls, on their way to boutiques in Hyannis, stumbled clumsily through loose sand to gaze at a corpse. For a day or two the normal human pattern was broken and a carnival atmosphere prevailed. But there was also a sense of pilgrimage in those trekking across the beach, an *obligation* to view such a thing. For what?

I could understand my own semi-professional interest in the whale, but what had drawn these hordes? There are some obvious answers, of course: novelty, a break in the dull routine, an old human desire to align ourselves with great and extraordinary events. We placed sweethearts and children in front of the hulk and clicked cameras: "Ruthie and the Whale." "Having a whale of a time on Cape Cod."

Curiosity is the simplest answer, but it evades the question. What, after all, did we hope to find out, and what did we learn by coming there? We were more like children at a zoo, pointing and poking. Yet, as the biologists looted its innards with vials and plastic bags and the media

people jousted for camera positions, we mere spectators also tried to *make* something of the whale. Circling the whale to fix some hold on its slippery bulk, we grappled it with metaphors and lashed similes around its immense girth: "It lay upside down, like an overturned trailer truck." It's black skin was cracked and peeling, red underneath, "like a used tire." The distended, corrugated lower jaw, "a giant accordian," was full with the gas of putrefaction and, when pushed, it oscillated slowly "like an enormous waterbed." Like our primitive ancestors did, we still tend to invent images to familiarize the strange.

But what were we looking at? What *we* saw in it might tell us why we had come. There were so many ways of looking at something so large. A male finback whale — *B. physalus* — a baleen cetacean. The second largest creature ever to live on earth. An intelligent and complex mammal. A remarkably adapted swimming and eating machine. A cause for conservationists. Perfume, pet food, and machine oil. A magnificent scientific opportunity. A tourist attraction. A media event, a health menace, a municipal headache, and a navigational hazard. Material for a column.

On the whale's own hide seemed to be written its life history, upon which we could remark but not read. The right fluke was almost entirely gone, lost in some distant accident or battle, and now healed over with a white scar. The red eye, unexpectedly small and mammalian, stared at us with a fiery blankness. Around the anal area were odd scratches or grooves, perhaps from scraping on the ocean bottom.

Yet the whale, dead, immobile, in full view, nonetheless shifted kaleidoscopically before our eyes. The following morning it was gone, efficiently removed like the week's garbage. What was it we saw?

Transcending Human Values

Having pondered the question a good deal, I can offer one answer, perhaps so obvious that we have ceased to recognize it. There is a growing tendency among conservationists to defend whales and other endangered species by pointing out their similarities to human beings. Cetaceans, we are told, are highly intelligent. They possess complex "languages" and have developed sophisticated communications systems that transmit effectively over long distances. They form family groups, extensive social structures, and personal relationships, expressing loyalty and affection towards one another. Much of their behavior seems to be recreational: they sing, they play. And so on.

These are not sentimental claims. Whales apparently do these things, as far as our very sketchy information about them warrants such interpretations. And for my money, any argument that helps to protect these magnificent creatures has merit.

But I take exception to this approach, not necessarily because it is erroneous but because it seems to me wrongheaded and misleading. Such an exclusive and anthropocentric approach denies the recognition of nature in her own right. It implies that whales and other creatures have value primarily insofar as they resemble man himself, and conform to his ideas of beauty and achievement. This attitude impinges on that of the old whalers themselves. To consume whales chiefly for their nourishment of human values is only a step from consuming them for meat and corset staves. It is not only presumptuous and patronizing, but it does both whales and human beings a grave disservice.

Moreover, such an attitude still leaves unexplained the throngs who came pell-mell to stare and conjecture at the dead whale that washed up and dominated Corporation Beach for two days. Surely we were not flattering ourselves, consciously or unconsciously, with any human comparisons to that rotting hulk.

No, it was precisely because the whale did *not* resemble us that we were drawn to it in such numbers. Man, I believe, has a crying need to confront otherness in the universe. Call it nature, wilderness, the great outdoors, or what you will — we crave to look out and behold something other than our own human faces staring back at us, expectant and increasingly frustrated. What the mind wants, as Robert Frost put it, "Is not its own love back in copy-speech, But counter-love, original response." This experience of otherness is, I feel, as necessary a requirement to our being as food and warmth is to our bodies. An individual, cut off from human contact and stimulation, may atrophy and die of loneliness and neglect. So mankind finds itself in a similar, though much more subtle, danger of cutting itself off from the community of creatures with which it shares the natural world. If our physical survival depends on a deeper knowledge and more rational use of the earth's resources and produce, our growth as a species depends equally on our establishing a vital and generative relationship with what surrounds us.

We need plants, animals, weather, unfettered shores, and unbroken woodland, not merely for a healthy and stable environment, but as an antidote to introversion, a preventive against human inbreeding. In the splendor of natural life we have an extraordinary reservoir of untapped possibilities and ways of experiencing life, of knowing wind and wave, of meeting the exactitudes of being. To confine that world to zoos or to exclusively human uses impoverishes nature, and ourselves as well. Through our technology we have abstracted ourselves from most of this direct experience of "otherness"; we have substituted human myth for natural reality, and we wonder why things go wrong and why we starve for nourishment. We veneer such naked meeting places as the open shore with phrases like "rural seaside charm" — until 40 tons of dead flesh wash ashore and give the lie to such thin, flattering conceptions. The stench of the whale is still the stench of life that stirs us instinctively to reaction and response, causing us to drop our business, abandon our vehicles, trample beachgrass, and ignore official barriers. We came to see the whale on the beach that day because it represented, in an unmistakeable dimension, that essential, unknowable "otherness" we both seek and recoil from. Its mute, immobile bulk shouted at us, more loudly than the policeman's bullhorn, that the universe is fraught, not merely with response or indifference, but with incarnate assertion.

Ironically, the forces of biology and engineering did not have any better luck grasping the whale than the rest of us did. Even in death it escaped us: the tissue samples taken for the analysis proved insufficient and the autopsy report stated that "we will never know why the whale died." The carcass, being towed by the Coast Guard cutter to the designated dumping ground, broke its six-inch towline and failed further attempts to reattach it. Even our powers of disposal, it seemed, were questioned that day.

Photo: Robert Finch

Robert Finch lives in Brewster, Mass., where he edits The Cape Naturalist *for the Cape Cod Museum of Natural History and writes a column of "Soundings" for the* Provincetown Advocate.

Books and Comments

Photo: Steve Glines

Changing Cities

The Adoption of Innovation by Local Government
Richard D. Bingham
Lexington, Mass.: Lexington Books, 1976, xiii + 271 pp.; no price

Reviewed by Louis E. Alfeld

Whenever I read a book I look for something of practical value. Not that I demand that every book include instructions on how to repair my Volkswagen; I consider books that help me to think more clearly to be practical, as well. Books that arrange ideas, organize concepts, uncover new relationships among familiar things, or explain causalities, possess practical value. Such books are particularly useful when they encourage more rational decisionmaking.

Books that help urban decisionmakers think more clearly and act more positively are rare. Unfortunately, *The Adoption of Innovation by Local Government* is not among them.

Innovation in local government sounds like an interesting topic for study. The subject immediately brings to mind such questions as, "Why does local government need to innovate?," "What innovations does local government need?," "What innovations have improved our cities?" To answer such questions, a researcher must first establish some sort of value system to point out what goals various innovations should achieve. With specific goals to order their discussion of innovation, urban administrators could decide which innovations to pursue and which to avoid.

Chronic Problems

Urban decisionmaking can improve when city administrators consider the long-term impact of their actions on city conditions rather than merely the short-term political implications of alternative actions. However, goals that stretch beyond the tenure of any single administration are difficult to define with enough clarity to convince urban policy designers. Yet long-range planning most needs an innovative boost.

For example, the three most critical chronic problems facing local government today are land use, differential population migration, and the aging and obsolescence of the city itself. These problems are most acute for older cities, but they also plague newer suburbs. Because nearly all the choice urban land has already been committed to use, new growth can occur only at very high cost. Usually land must be cleared before rebuilding. Alternatively, the mediocre quality of remaining open land requires its extensive — and costly — preparation. The depressing effect of limited land availability inhibits the continual rebuilding and replacement so necessary to keep the city functionally efficient and economically competitive.

Without constant, significant new construction, the average age of existing city structures lengthens. Aging and obsolescence rob these structures of their vitality. As older residential structures slip to the bottom of the market, they are filled with tenants of lower and lower socioeconomic status. As older business structures deterioriate, their economic contribution, both in terms of jobs and taxes, disappears.

Urban decline tends to increase lower income housing opportunities while decreasing the number of blue collar jobs. More people and fewer jobs result in higher unemployment, increased poverty, and soaring taxes.

As the older city declines, it becomes less attractive to middle and upper income families: they move out (or don't move in). Differential migration patterns fill the city with underemployed, attracted by wider housing and job choices. They find cheap housing but seldom find lucrative employment. Welfare, crime, and drifting become a way of life for many of the city's poor.

Technological Toys

Innovations which help a city attack the chronic causes of its problems certainly rate further study. Innovations, for example, which speed the demolition process and reduce the costs (social as well as economic) of land clearance and assembly for redevelopment merit attention. Similarly, innovations which slow the aging and obsolescence of structures are sorely needed. Rehabilitation, code enforcement, and neighborhood conservation all demand creative thinking. Innovative ways to restore the faith of the middle class in the city's future also deserve high priority.

Urban decisionmakers ought to be interested to learn which innovations to undertake and why those innovations will help their cities. Instead, most innovation research focuses only on what has been done and ignores what should be done.

Mr. Bingham's book is an example of this limited point of view. The book discusses only two relatively unimportant questions: "Why do some local governmental units readily adopt technological innovations while others virtually ignore them?"; "What are the processes usually followed in adopting innovation?" The questions are trivial because the book employs regression analysis of aggregate social and economic data to discover why an innovation is adopted — and concludes that "intergovernmental assistance, fiscal and otherwise, and resource levels are the most important direct contributors to innovation commitment." In other words, the more money you have, the more likely you are to spend it on fancy new hardware and computer processing systems. But new technological toys do not address the real issues of survival facing cities today. Worse yet, fascination with "technology transfer" often diverts energy and resources away from the fundamental forces that shape our cities.

A Place in the Closet

The failure of much urban research to address the questions that city managers, mayors, and city councils ask tends to isolate planners from the inner circle of urban decisionmakers. For a city planner to tell a mayor that his city's demographic profile indicates the city should or should not adopt a particular innovation will guarantee the planner a place in the closet. The decisionmaker such as myself is looking for practical answers to practical questions. If my Volkswagen doesn't start I want to know the relative costs and ben-

efits of repairs versus trade-in — not just for the short term, but also for the long term. If the mayor's constituents are suffering from unemployment and high taxes, he wants to know how to provide jobs and cut costs. Any short-term viewpoint can recommend the waiver of local zoning requirements to get a construction job going and can propose cuts in an ongoing street maintenance program. But what measures will bring continuing economic health?

Planners, uniquely, should be able to propose solutions that address the *causes* of problems, and justify their solutions against stop-gap alternatives designed only to meet the demands of political expediency. Books written for the people who plan and run our cities do far more to improve the quality of urban life than do books written for other academics.

Louis E. Alfeld is Director of Construction Industry Programs for the National Center for Productivity and Quality of Working Life. He is former Director of Planning and Community Development for Marlboro, Mass., and was Director of Urban Dynamics Research at M.I.T. from 1970 to 1975.

Shirt Buttons, Broken Bottles

Industrial Archeology: A New Look at the American Heritage
Theodore Anton Sande
Brattleboro, Vt.: Stephen Greene Press, 1976, 152 pp.; $18.95

Reviewed by Electa W. Kane

At worst, industrial archeology is a nostalgic attempt to uncover the past "because it is there." At best, it is an interdisciplinary study of our technological development, as evidenced in the material remains of our industries.

The subjects of industrial archeology may range from prehistoric evidence of craft production to turbine engines which have become obsolete only recently. The discipline's techniques are as varied as its interests: classic archeological excavation, historical documentary research, architectural survey and recording, sophisticated technical analysis, or even the methods of civil engineering.

Only within the past decade has any serious attempt been made to define and professionalize this new field. In 1959, the Council for British Archaeology established a Research Committee for industrial "monuments," and began to survey and record extant industrial sites throughout Great Britain. An international Society for Industrial Archeology, headquartered at the Smithsonian, was founded in 1971, and is currently the major coordinating agency for American research in the field. R. A. Buchanan's 1972 publication, *Industrial Archaeology in Britain,* offered to amateur and professional alike the first cogent conceptual framework for research and fieldwork. Dr. Buchanan's essays on the definition and history of industrial archeology, and on the "Industrial Revolution" debate have yet to be surpassed, while his national survey of industrial sites provides a broad context for appreciation of specific regional or site investigations in Great Britain.

Going Underground

Prior to Theodore Sande's *Industrial Archeology,* no such broad-based introduction had been attempted for materials in the United States — a lack which has been sorely felt by students of the industrial past wishing to understand the field's scope.

Dr. Sande offers fascinating glimpses of a wide variety of industrial and commercial sites, the majority dating from the mid-19th century and later. These range from a surprising wood-frame oil rig (West Virginia, c. 1895-99), through an impressive and carefully detailed array of early 20th-century dams, to a bewildering variety of recently obsolete manufacturing and power plants, transportation networks, and raw-materials processing sites.

Dr. Sande's visual presentation is flawless, and his appendix on "Selected American Industrial Sites" is a helpful state-by-state survey of significant manufacturing and commercial sites drawn from the files of the Historic American Engineering Record.

For all this, *Industrial Archeology* is disappointing. Dr. Sande's own training as an architectural historian leads him to present industrial archeology as an "above-ground" pursuit of fixed architectural and engineering monuments. He presents a photo essay on the Colt Armory in Hartford, Conn., but does not mention the recent excavation of the Eli Whitney Gun Factory in the same city, which challenges the myth of industrial revolution in America. He includes 19th-century coke and blast furnaces, but the Hopewell Village Historical Site, which has been extensively researched and which represents a century and a half of iron production, is acknowledged only in the appendix.

Although Dr. Sande thinks industrial archeologists should interpret sites in order to "comprehend the full range of past methods, production, working conditions, daily life, social patterns [and] economic organization," he does not suggest how this interpretation may be accomplished.

Industry in the United States is as old as the nation's history. One of the original goals of English settlement was to estab-

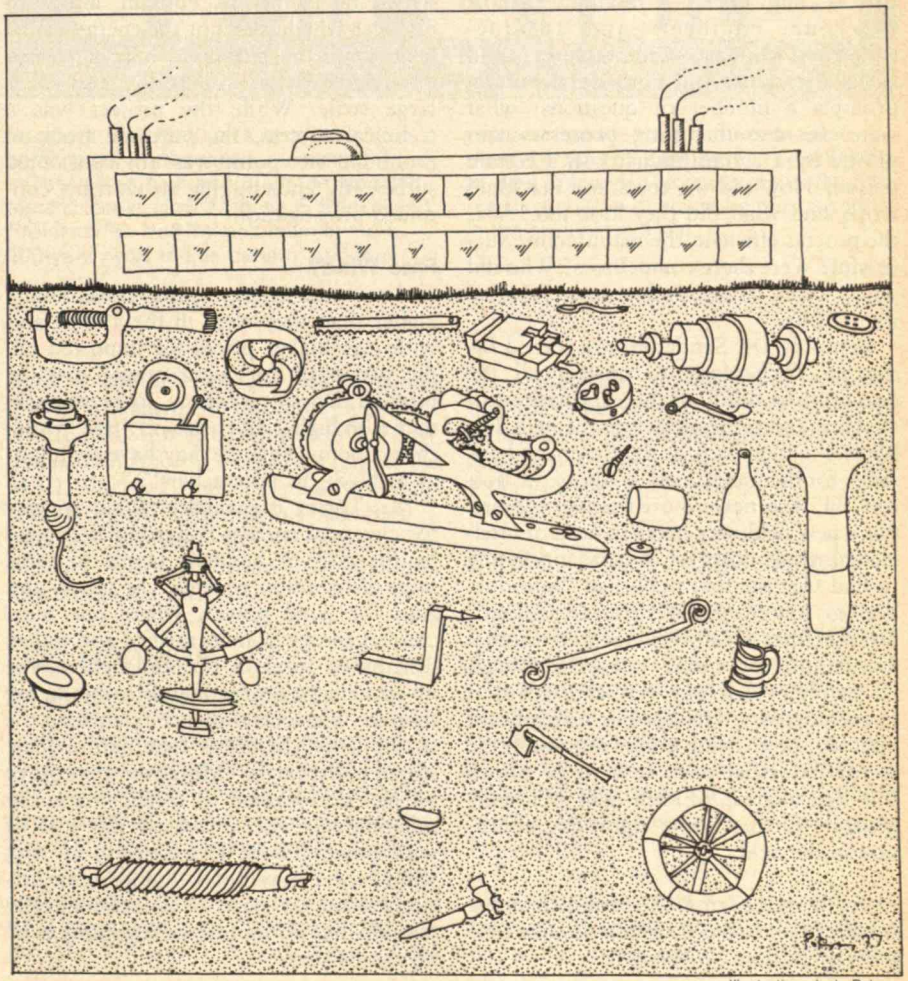


Illustration: Judy Pokras

lish manufacturing enterprises where raw materials and fuel, both depleted in England, were plentiful. As settlement expanded and the country moved toward economic self-sufficiency, industrial development was a major source of contention between colonies and the mother country. At the same time, American entrepreneurs were discovering that more was required for successful manufacturing than ready raw materials.

The pre-Revolutionary period of American industrial history, with its many failures and few dramatic successes, offers a rich field for investigation by the industrial archeologist. It is only against this background that the rapid expansion and high success rate of industry in the 19th century can be appreciated fully.

Understanding the industrial past certainly begins with an understanding of the industrial site, as Dr. Sande points out. That "industrial site," however, comprises more than the monumental remains of buildings and fixed machinery. It includes the moveable artifacts of production and producer (finished product, by-products, tools, shirt buttons, broken bottles), the topographic context of the site (raw materials, transport routes, proximity to markets, food and fuel resources), and the socio-economic framework within which the industry operates.

Within this broader definition of industrial archeology there is material which can — and does — fascinate almost everyone: engineers and antique-collectors, modern manufacturers and social historians. And a broader definition prompts a number of questions: what were the manufacturing processes employed by a certain industry in a certain period? How did the tools and machines work, and what did they look like? Was the process efficient, the manufacture successful? Were there competitors? Who did what, when, where, and — most perplexing — why?

Certainly Dr. Sande did not intend *Industrial Archeology* to answer all the questions or fulfill all the expectations of students and professionals in the field. His book is a "new look at the American heritage" for the uninitiated to whom the Boston "El" was never more than an eyesore. For a new field very much in need of intellectual roots, however, it is disappointing to find that the first published "introduction to American industrial archeology" offers neither a historical nor a conceptual foundation for future research, though Dr. Sande's work may well serve as a spur to such activity. His book is a significant indicator of growing public interest in the recent industrial past. It is to be hoped that that interest, of itself, will eventually generate further, more rigorous publication in the field.

Electa W. Kane is a Ph.D. candidate in the American and New England Studies Program of Boston University.

Windmills from Grandpa's Knob to Plum Brook

Wind Catchers: American Windmills of Yesterday and Tomorrow
Volta Torrey
Brattleboro, Vt.: Stephen Greene Press, 1976, 226 pp.; $12.95

Reviewed by John B. Wilbur

"Wherever wind has a chance to develop great strength — on islands, open plains, smooth coastal shores, and in deserts and mountain passes it may soon run many [electric] generators," writes Volta Torrey in his introduction to this compendium of windmill lore and development. Mr. Torrey goes on, "Dr. Homer J. Stewart of Caltech believes that the wind's potential for energy production is several times that of the electrical plants serving this country today." But the important question is, as Mr. Torrey points out, whether wind can compete economically with other power sources.

This question was central when the 1,000-kw Smith-Putnam Wind Turbine was built and tested during the early 1940s on Grandpa's Knob near Rutland, Vt. That venture, sponsored by the S. Morgan Smith Co. of York, Penn. and designed by Palmer C. Putnam, aimed to discover whether or not the energy of the wind could be harnessed and converted into electricity economically, and on a large scale. While the project was a technical success, the outcome from an economic viewpoint was not considered sufficiently encouraging to warrant continued investigation.

Free Wind?

Today, with energy costs substantially higher than they were in the 1940s, and with ever-higher prices for imported oil, the prognosis for wind power may be brighter. Doesn't it follow, some may ask, that with higher oil costs and "free" wind, the economic balance may have swung so as to favor "wind catchers"?

Mr. Torrey is realistic. "What we pay for electrical current is partly determined by the cost of building plants to serve large distribution systems," he points out. And for wind power, where one must convert energy from its rarified and widely distributed form in the atmosphere, the investment is almost bound to be higher than in "big central plants exhausting the stockpile of chemicals that nature [has] stored in the earth." Moreover, the cost of oil has skyrocketed in recent years, but inflation has also increased the cost of wind power plants. This is not to say that wind power may not — under some circumstances, at least — be economically feasible, but rather that its feasibility is by no means sure.

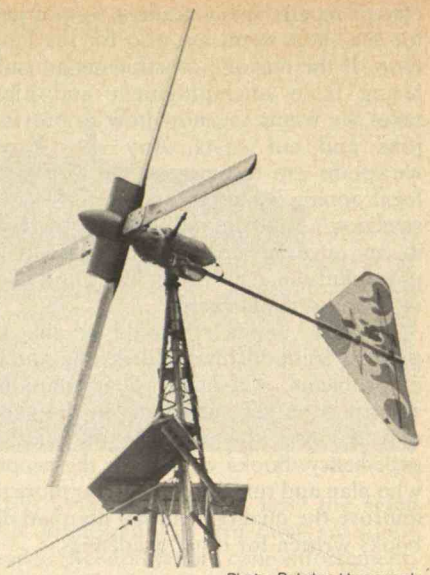


Photo: Bohdan Hrynewych

Our best chance to find out more about the current competitive position of wind power undoubtedly lies in the 100-kw pilot wind generator that has just been built at N.A.S.A.'s Plum Brook facility. While this new installation has features similar to the earlier Smith-Putnam unit (e.g., a propeller with two variable pitch blades mounted on the downwind end of a cabin that is pivoted on a tower top), it also takes advantage of the many advances that have been made in aeronautical, materials, and meteorological technologies during the intervening years. Mr. Torrey reports that Joseph Savino (the engineer in charge) and his staff are "now getting some significant and encouraging results from tests of the generating system and other components," and that E.R.D.A. now hopes to decide by early 1977 "on which of the 17 proposed sites it will authorize construction of more big wind plants."

Grandpa's Knob Vindicated

Beauchamp E. Smith, President of the S. Morgan Smith Co. during the Grandpa's Knob experiment, was a special guest at the dedication of the Plum Brook plant. "When we came through the gates today," Mr. Smith told a reporter, "I got a feeling of great satisfaction. I've always felt that something good would come out of our tests, even if we were somewhat ridiculed at the time, when energy sources seemed to be more abundant than our country would ever need. We were just ahead of our time." And Mr. Savino, who in addition to his Plum Brook assignment is Chief of the Power Applications Branch of N.A.S.A.'s Lewis Research Laboratory in Cleveland, is convinced that "with a few hundred thousand more dollars, the S. Morgan Smith Co. might have developed a power plant that would be helping utility companies to meet peak loads economically today."

(Continued on p. 17)

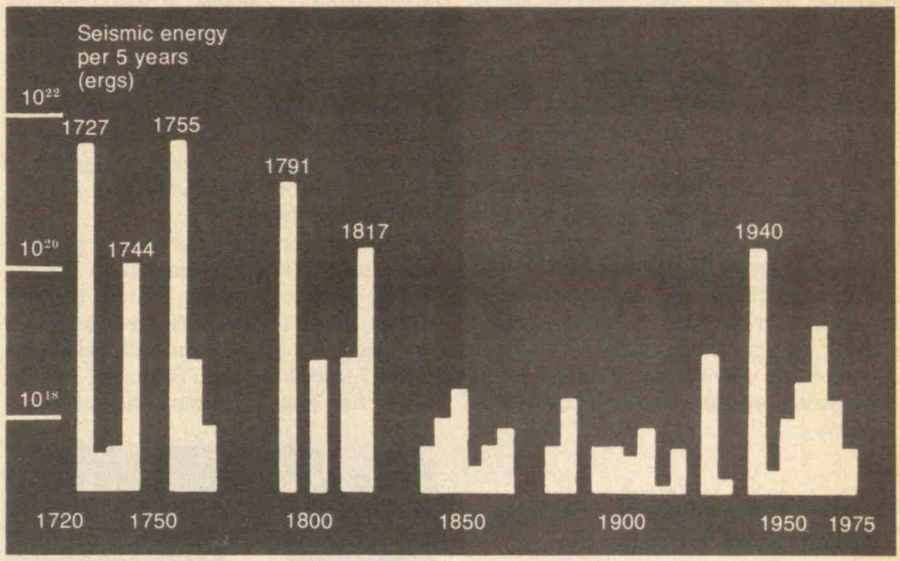
An Institute Informant

Earthquakes Ahead for New England?

Parts of southern New England are classified as areas of high seismic hazard, but there have been almost no significant earthquakes here in more than a century. Intrigued by this apparent anomoly, Anthony F. Shakal and Professor M. Nafi Toksöz of the Department of Earth and Planetary Science dug into the history books — New England, settled early, has the longest record of reported earthquakes in the U.S.

They found that the seismic energy released in earthquakes in an area bounded roughly by the White Mountains, Montpelier, Vt., Fall River, Mass., and Cape Cod has fluctuated with time in a cycle which appears on inspection to be about 50 years.

But an analysis by the extreme-value method shows a periodicity of about 180 years. Earthquake activity was clearly higher between 1725 and 1850 than at any time since, and Mr. Shakal and Professor Toksoz think the "marked increase" in earthquake energy release observed since 1940 "could represent the beginning of another episode of seismic activity in southern New England."



Southern New England's history includes some major earthquakes — epicentral intensities as high as VIII on the modified Mercalli scale. Now Anthony F. Shakal and Professor M. Nafi Toksoz have found a 200-year cycle in this pattern, and they propose that the more intense seismic activity of the 18th century may be returning to New England. The dates above the bars are those of the principal tremors recorded in the area since 1725.

Fuel Bills: Cutting the Bitter News

In the bitter winter of 1976-77, an average seven-room single-family New England home cost $850 to heat; that's compared to $650 in 1975-76, when the weather was abnormally warm and fuel prices a bit lower.

When President Jimmy Carter asked that thermostats be turned down to 65° (and 55° at night), Professor John J. Donovan — he had just completed the computations reported above — turned on his computer again. The new suggestion would save $129.20 — 15.2 per cent of home-heating fuel demand, he found. "People should do what he says," Professor Donovan concluded.

Professor Donovan's data were drawn from a computer-based New England Energy Management Information System (N.E.E.M.I.S.) first developed in 1973 by the Sloan School of Management and the M.I.T. Energy Laboratory; the New England Regional Commission has been a principal sponsor, with large-scale assistance from International Business Machines Co., Inc.

Los Angeles Energy Symposium

Energy supplies and energy policy will be the focus of a symposium arranged by the M.I.T. Club of Southern California in Los Angeles during the afternoon of Saturday, June 18. Among speakers will be David C. White, Director of the M.I.T. Energy Laboratory; Henry D. Jacoby, Professor of Management, a specialist in energy policy; and William F. Pounds, Dean of the Sloan School of Management. The meeting will utilize conference facilities of the Aerospace Corp., El Segundo Blvd.; information is available from Syed M. S. Alvi, 8844 Orion Ave., Sepulveda, Ca., 91343.

Inner Cities Lose Again

When the Nixon administration proposed federal "revenue sharing" for community development in 1974, the idea was to award money in block grants so that local governments could use it quickly in accordance with their local understanding of where it was most needed. Inner-city programs were to be emphasized, and one specific objective was to help low-income householders.

But it hasn't worked that way.

Local governments have enjoyed their freedom, of course, but they have used it in just the opposite way — "to shift funds

quickly from poverty neighborhoods to other parts of the city, with at least tacit federal approval," says a report from the M.I.T.-Harvard Joint Center for Urban Studies.

"And despite the rhetoric of local government control," write Professor Bernard J. Frieden of M.I.T. and Marshall Kaplan of the consulting firm of Kaplan, Gans, and Kahn in the Joint Center report, "national policy is encouraging the use of federal money for public works projects and discouraging its use for public services."

Examples: a tennis complex in Arkansas, a convention complex and garage in Spartanburg, S.C., and a fire station in Gulfport, Miss. — all built with money designed to help low- and moderate-income people.

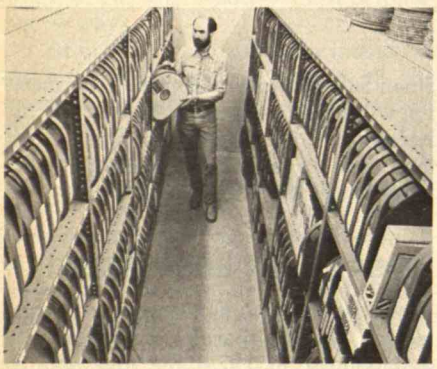
The program, says the M.I.T. report, "is doing less than it could and much less than Model Cities (its predecessor) did to give poor people a piece of the action."

Professor Frieden and Mr. Kaplan do not suggest dismantling the block grant system called Community Development Revenue Sharing. They consider it "a legitimate format for federal aid to urban areas," and they'd like to see a series of safeguards in the law — for example, a specific minimum percentage of funds to be used for low-income families or in low-income neighborhoods in each community.

A Catalog of 500 Tapes and Films

More than 500 lectures, demonstrations, and study guides on videotape, film, and/or paper are now available for rent or purchase from M.I.T.'s Center for Advanced Engineering Study, and all are listed in a new comprehensive catalog of its instructional materials, both refresher and "state-of-the-art" courses.

New listings in the catalog include "Building an Innovative Organization," "Cooling of Electronic Equipment," and "Quality Control"; best-sellers in 1976 were "Digital Signal Processing," "Colloid and Surface Chemistry," and "Management of Technological Innovation." For copies of the catalog, write to C.A.E.S., Department 9, Room 9-150, M.I.T., Cambridge, Mass., 02139.



Among thousands of videotapes, films, and documents in the new catalog of the Center for Advanced Engineering Study, the most ambitious is the 55-lecture series on Colloid and Surface Chemistry by Professor J. Th. G. Overbeek of the University of Utrecht. It's preserved in the form of the broadcast-quality master videotapes shown in this picture, and this winter C.A.E.S. made the first sale of the complete 55-tape series. The purchaser: the University of Akron; price, $12,800.

Computing for the Blind

Instead of showing its messages and results on a video screen, this computer manipulates a console of metal pins to provide its communications in Braille. It's a simple new invention for making the power of computers available to the blind — and for giving blind people new employment opportunities — developed by Professor Derek Rowell, Director of M.I.T.'s Sensory Aids Evaluation and Development Center.

The first application is now in place: a blind person is being trained to use the Traffic Service Position System through which most operator-assisted calls are handled at Southwestern Bell Telephone Co. in Little Rock, Ark. A normal T.S.P.S. board has some 90 lamps and push buttons to indicate the nature and status of the calls the operators are handling. Now this computer-assisted console provides the same information for a blind operator through a set of solenoid-operated pins; 12-character Braille messages alert the operator to all changes in the status of the console.

A tiny computer is used to program the pins in the foreground (each is either raised or lowered) to form Braille characters. Thus the output of a large computer can be translated from visible to Braille and countless new opportunities in education and work opened to the blind, thinks Professor Derek Rowell (rear), Director of the M.I.T. Sensory Aids Evaluation and Development Center. This first application of the computer-driven "Braille video display" was designed by George Dalrymple (foreground), engineer at the Center, for Southwestern Bell Telephone Co.'s Traffic Service Position System, of which a mock-up is shown.

The Rehabilitation Services Administration of the Department of Health, Education, and Welfare which (with the E. Matilda Ziegler Foundation) sponsored Dr. Rowell's work is enthusiastic: as many as 200 to 300 blind people could be employed throughout the nation as T.S.P.S. operators. And George Dalrymple of the M.I.T. Sensory Aids Center thinks the invention can open to blind people work as computer programmers, reservation and inventory clerks, and taxpayer service representatives — "any job that enters, manipulates, or retrieves data of programs stored in a remote computer."

Nisbet

Continued from p. 5

vegetables and fibers. Recent studies suggest a similar risk for diets that emphasize beef and pork. The types of cancer involved are amongst the most frequent and most rapidly increasing: cancer of the colon and rectum in males, and breast cancer in females.

The issue of meat consumption and cancer is reminiscent of the controversy over smoking and cancer in 1952. The statistical association is becoming steadily clearer, but definite evidence for a cause-and-effect relationship is still quite weak. It is certainly not clear whether the causative agent(s) are animal fats, meats themselves, diets low in fibers, preservatives, contaminants, or some other factors which happen to be associated with western diets. However, prudent and knowledgeable people are now altering their diets, just as they cut back on smoking in the early 1950s.

The increasing demand for meat in the U.S. and other affluent countries thus contributes to an amazing range of environmental problems: cancer, stream channelization, energy shortages, oil spills, soil erosion, ozone depletion, water pollution, public land use, and economic policy. Without a reversal of the subsidies provided to meat producers via unrealistic grazing fees, low water charges, and artificially low prices for petroleum, lasting solutions to these problems are unlikely. But we can help by eating less meat. Most of us would be better off eating more cheap vegetable protein and less fatty meat, in any case.

After all, the machismo associated with eating big bloody steaks should be no

more lastingly impressive than the machismo that used to be derived from smoking 25 years ago.

Ian C. T. Nisbet is Associate Director of the Scientific Staff for the Massachusetts Audubon Society; he writes regularly for Technology Review.

Norman

Continued from p. 9

the idea to Congress. Two other selling points: ocean drilling could help to elucidate the mechanisms causing earthquakes, and it could help us locate oil, gas, and other mineral deposits. These assets should make the program easier for Congress to swallow.

Colin Norman is Washington Correspondent for Nature *and a regular contributor to the* Review.

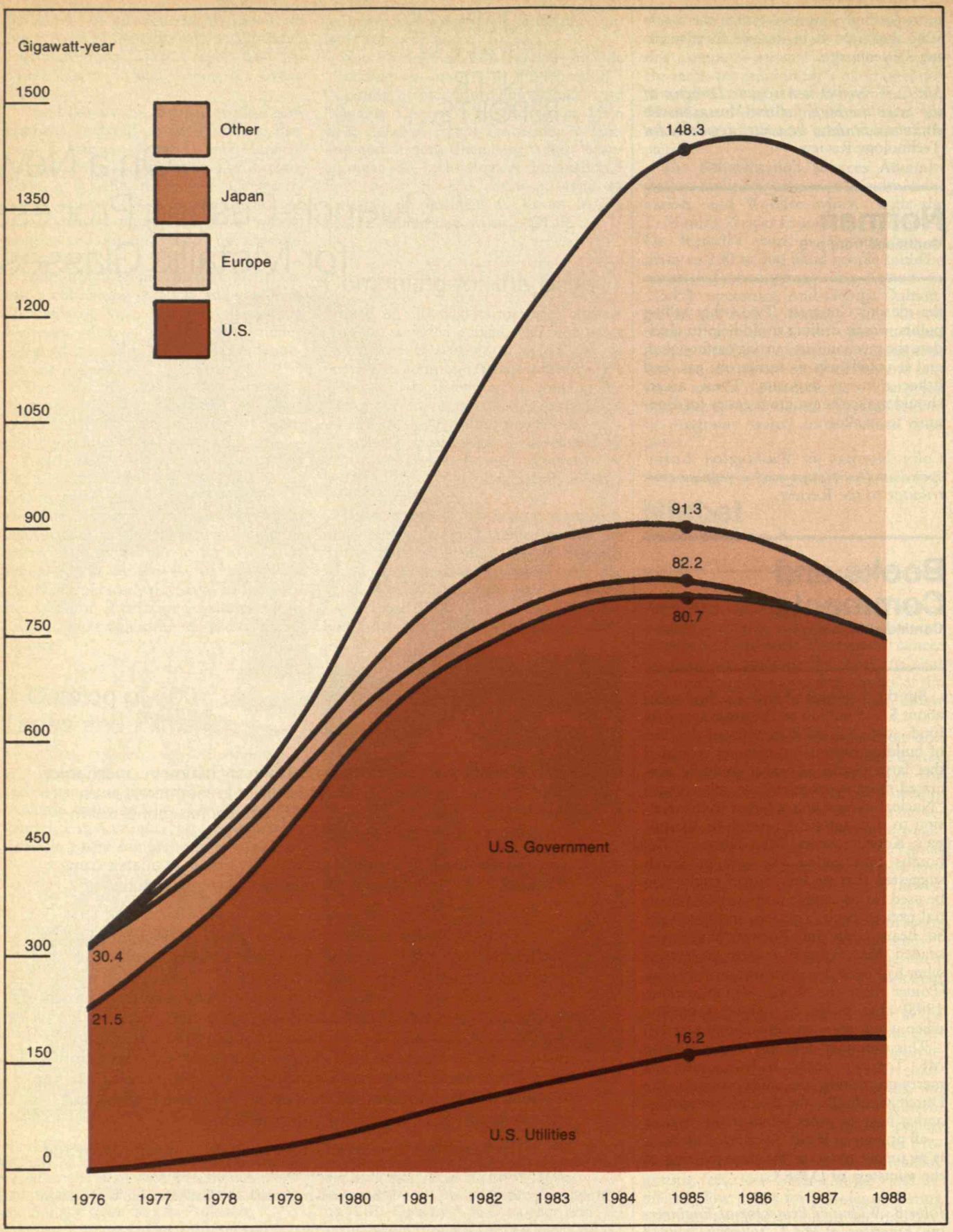
Books and Comments

Continued from p. 14

But the S. Morgan Smith Co. had spent about $1.25 million on the project, and its funds were limited. Estimates of the cost of building more wind turbines indicated that large blocks of power could be generated more economically in other ways. "Nuclear energy was a factor in the decision to dismantle the turbine on Grandpa's Knob," writes Mr. Torrey. "The bombs that ended the war in Japan suggested that nuclear power could also be used for peacetime purposes. Its potential excited both engineers and investors. So Beauchamp and Burwell Smith persuaded Mr. Putnam merely to review what had been done in a technical treatise [*Power from the Wind,* Van Nostrand, 1948] that might be helpful sometime when winds were strong and fuel scarce."

This summary does less than justice to Mr. Torrey's book. It leaves out the merry-go-rounds, the mills-on-posts, the Dutch windmills, the English windmills, and a host of other wind-driven devices —all present in *Wind Catchers.* The book is as timely today as the next meeting of the ministers of O.P.E.C.

John B. Wilbur is Professor of Engineering, Emeritus, at M.I.T., where he headed the Department of Civil Engineering from 1944 to 1960. He was a consultant for the Smith-Putnam Wind Turbine Project throughout its duration, and served as its Chief Engineer from 1942 to 1945.



Attainable stocks of light-water-reactor fuel in the coming years. The calculation is made by projecting a maximal production of uranium enriched in U-235, and subtracting from it the quantities of fuel consumed by the population of reactors forecast by the author. Two measures of the stockpile's value are given: the vertical axis plots gigawatt-years, that is, the amount of electricity whose generation the stockpile will support. The figures near the curves are millions of SWUs — that is, the amount of separative work employed in enriching the fuel.

Henry D. Jacoby
Professor of Managment
M.I.T.

An analysis of uranium supply for the coming decades suggests that nuclear fuel could be stockpiled and marketed, perhaps under international control, as part of an effort to counter the threat of nuclear proliferation.

Uranium Dependence and the Proliferation Problem

Is the supply of nuclear fuel for commercial power reactors growing insecure or inadequate? Many nations seem to think so, and as a result two worldwide trends are appearing. First, many nations are more anxious than ever to gain access to nuclear fuel processing technology, including uranium enrichment and spent-fuel reprocessing. In this way they hope to loosen their ties to foreign suppliers. Second, many nations are encouraging the development of the so-called breeder reactor, which would have a drastically reduced requirement for uranium fuel.

Unhappily, both of these responses to energy supply problems have a significant spillover in another area of international concern — nuclear weapons proliferation. For the fuel-cycle facilities are a possible source of weapons-grade uranium and plutonium, and the advent of the breeder would require a large supply of plutonium. Of course, the proliferation problem would exist quite apart from these influences, but the fear of dependence on uncertain supplies of commercial nuclear fuel only makes matters worse.

Much of the insecurity derives from expectations that the world's reactor population will grow very rapidly in relation to known uranium supplies, and is heightened by events suggesting a wavering supply from the established nuclear industry, particularly in the U.S. But over the past year to 18 months, conditions have been changing significantly. Though official recognition of the fact is slow to come, fuel supply prospects are now much less worrisome than they seemed only recently. Accordingly, opportunities now exist, through the establishment of stockpiles and other measures, to increase confidence in the security of the international fuel cycle, and thus to lower the pressures that seem to be leading to increased proliferation. However, there are costs and complex problems of management that must be faced if these opportunities are to be grasped.

Aspects of "Dependence"

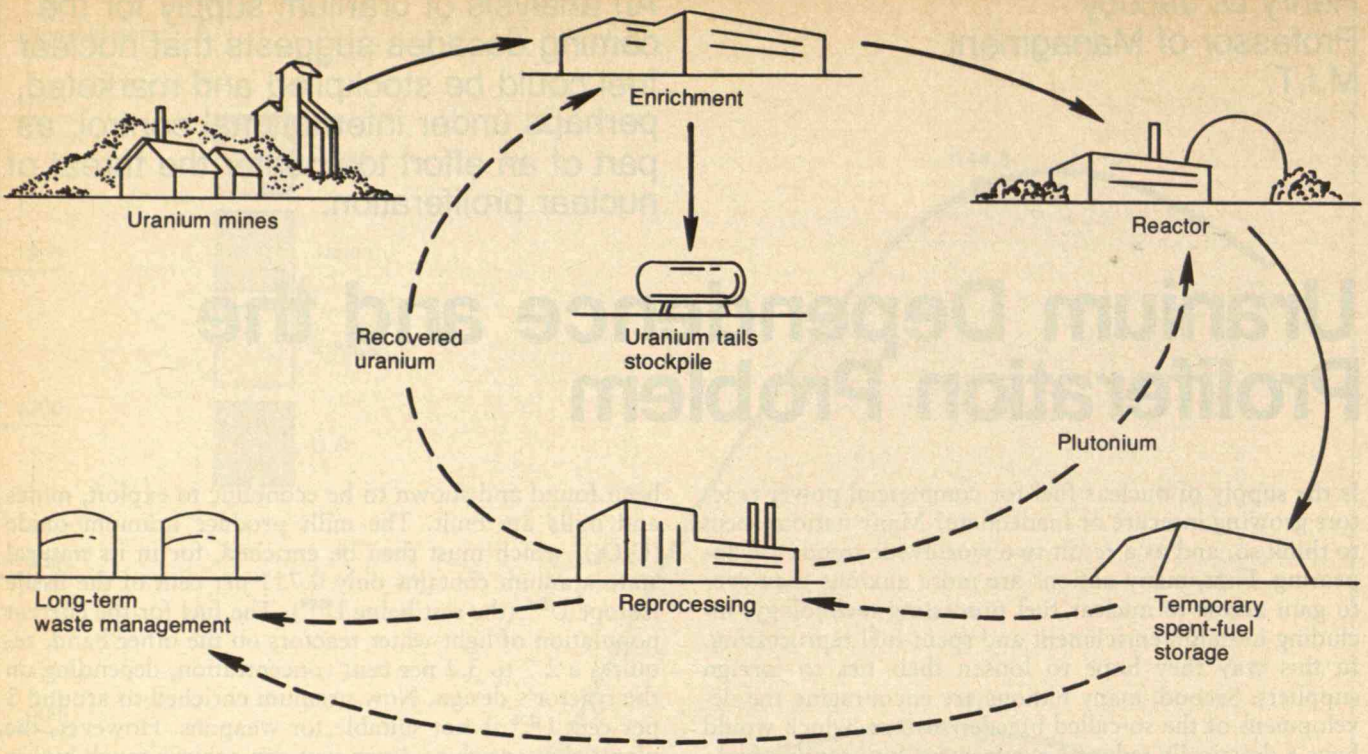
All nations rely on international trade for supplies of critical goods and services. Thus one seldom speaks of "dependence" in a pejorative sense unless there is a threat that supplies may be cut off, or made available only at unacceptable cost. Yet in the case of reactor fuel, expressions of concern about dependence are common.

The Fuel Cycle. The system supplying light-water reactors with fuel is shown on page 20; solid arrows indicate the flow of materials in the current U.S. nuclear program. The system operates as follows: when uranium resources have been found and shown to be economic to exploit, mines and mills are built. The mills produce uranium oxide (U_3O_8), which must then be enriched, for in its natural state uranium contains only 0.711 per cent of the fissile isotope U^{235} (the rest being U^{238}). The fuel for the current population of light-water reactors on the other hand, requires a 2.7 to 3.2 per cent concentration, depending on the reactor's design. Now uranium enriched to around 3 per cent U^{235} is not suitable for weapons. However, the plants that enrich to 3 per cent can achieve much higher percentages if suitably modified (indeed, most current enrichment plants were built as part of weapons programs).

The 3-per-cent (or "low enriched") uranium is fabricated into fuel rods in a step not shown in the illustration, and fed into reactors. Spent rods are held (at present) in temporary storage at the reactor site. Along with a number of other fission byproducts, they contain some residual U^{235}, and also a new element created in the fission process — plutonium. By means of chemical separation, the uranium can be extracted, sent back through the enrichment step, and placed again in a power reactor. So, too, can the plutonium be extracted. Plutonium, like U^{235}, is a fissile material, and can be fabricated with U^{235} into new fuel rods, in which case the rod is usually referred to as containing "mixed-oxide fuel." The plutonium extracted by the chemical separation process is suitable for weapons.

As indicated by the dashed lines in the illustration, fuel-rod reprocessing is not in use on a commercial basis in the U.S. Whether it should ever be done at all is a matter of active dispute and discussion. One complicating aspect of the debate is the fact that plutonium is a necessary element in our current design of the breeder reactor: the breeder is designed to produce large quantities of plutonium from U^{238} (recall that U^{238} constitutes the bulk of naturally-occurring uranium). The capital costs of the breeder are higher than those for the light-water reactor, but the requirements for uranium fuel are greatly reduced.

One further note on the fuel cycle: As part of his overall energy program, President Carter has declared that the U.S. will defer indefinitely the recycling of spent fuel in U.S. power plants. Moreover, the commercial demonstration of a breeder reactor has been delayed indefinitely, and research and development funds are being redirected from the plutonium breeder to other types of nuclear systems which might prove to entail less of a proliferation risk. Administration policy appears to follow very closely



The nuclear fuel cycle for light-water reactors. Solid lines show the steps currently in use in the U.S.; dashed lines show the steps required to "close" the cycle. Uranium is first mined and milled (upper left of the diagram). It then passes onward to an additional step — enrichment — for natural uranium contains too little of the fissile isotope uranium-235. After enrichment, the fuel is fabricated into rods and enters the reactor. At present, it is placed only in temporary storage when its power-producing life is done. If, however, the fuel cycle were to be closed, the rods would be taken to a reprocessing plant, where uranium and plutonium would be recovered. The former would return to the enrichment plant; the latter, a fissile material (and a radiological poison), could be fabricated into fuel rods.

the recommendations of a Ford Foundation Nuclear Energy Policy Study Group, published in *Nuclear Power Issues and Choices* (Ballinger, 1977). Whether other nations will follow suit is problematical.

The Status of Uranium Supply. The table on page 21 shows the major sources of uranium today and in the near future, along with a rough indication of estimated resources at a cost of $66 per kilogram ($30 per pound) of U_3O_8. As the table shows, the U.S., Canada, Australia, and South Africa now dominate, though there is considerable uncertainty as to their relative roles in the future.

Several additional uncertainties should also be mentioned. In Australia and Canada policy changes have been made in recent years, and large blocks of reserves have been removed from the international market. In Australia, new export commitments have been forbidden for some years, pending the resolution of a host of issues, including public-private ownership, environmental problems, the role of foreign capital, and the desire to enrich uranium domestically as opposed to simply exporting it. In Canada, exporters can now draw only upon a margin of proved reserves beyond the total uranium needs for a full 30-year life of all Canadian reactors existing, committed, or planned to be installed over the next ten years. Given the long time-horizons for exploration and for the development of mines and mills, these provisions effectively remove Canada from the world market, at least for the next few years.

A portion of known and potential uranium resources is also found in less-developed countries. In some cases export supplies are insecure due to inherent political instability; in others the problems are akin to those of Australia, where internal issues of equity, environment, and economic growth are yet to be resolved.

As a result of all these uncertainties, many consumer nations fear that uranium trade simply will not create a market similar to that which has developed for most other international commodities. Is this concern warranted? Considering the fact that uranium is highly dispersed about the world, one would expect the development of a diverse set of suppliers. Indeed, there is no geological reason to expect that uranium is concentrated in so few countries as the table shows. More likely, the areas with large known reserves have been more carefully explored, for they tend to lie within the developed nations. Uranium has thus far been found in over 30 countries, and even now it is generally accepted that only 15 per cent of the earth's land surface has been well explored for uranium. The degree of concentration of supply shown in the table should decrease as existing small producers expand and as new countries enter.

Now if these developments are likely, then there is no reason in principle why an international market for uranium should not "work," in the sense that suppliers and customers could trade with one another through a combination of spot transactions and long-term contracts. If this were to happen, then the issue of future access to supplies in the market would not arise; the only question would concern future prices, and these could reasonably be expected to be set by competitve forces. After all, most nations are dependent to some degree on international supplies of critical raw materials such as oil, natural gas, and imputs for industrial processes. Nations

	Annual production capability		Resources	
	Current	Attainable in 1978	Reasonably assured	Estimated additional
United States	16,300	22,400	578,000	967,000
Australia	—	2,360	389,000	94,000
Sweden	—	—	354,000	—
South and Southwest Africa	4,480	13,000	330,000	—
Canada	7,660	10,000	200,000	719,000
Argentina	191	608		
France	2,120	2,590		
Gabon	708	1,420		
Germany	290	290		
Japan	36	36	342,000	366,000
Mexico	—	290		
Niger	1,769	1,770		
Portugal	109	127		
Spain	172	399		
Yugoslavia	—	272		
Other	—	—		
Total:	33,800	55,600	2,190,000	2,150,000

The capability of the world's uranium mining and milling industry, and an estimate of the world's uranium resources. The U.S.S.R. and China are excluded. All figures are given in metric tons of uranium oxide (U_3O_8). Figures for annual production capabilities are taken from *Nuclear Fuels Supply*, Edison Electric Institute, March, 1976. Figures for resources are taken from R.D. Nininger, "Uranium Availability," presented at the International Conference of the Atomic Industrial Forum, November 17, 1976.

build large installations which rely on imports, yet make no attempt to tie down supplies for the economic life of the capital facilities. The normal concern is to negotiate firm contracts for reasonable lengths of time; the contract period rarely extends very far beyond the time required to bring on new sources of the particular commodity — say, a decade. Often the contract period is much shorter.

Of course, there is always a special sensitivity to dependence on foreign sources of energy materials, for energy affects all sectors of the society, and not just one installation or industry. The concern about oil dependence, for example, is universal, and the oil problem adds urgency to the uranium issue, if only because it is possible for any given nation to achieve autarky in the nuclear power cycle. Moreover, the fact that the market for uranium can perform adequately "in principle" does not imply that it will indeed do so.

The Availability of Enrichment Services. One circumstance makes nuclear fuel different from other commodities: a crucial step in its processing — namely its enrichment — is available almost solely in the United States. Only a small capacity exists in Europe (and it will remain small for another few years), and only a portion of the U.S.S.R. capacity is available to produce fuel for export.

Throughout the early years of the nuclear industry, it was U.S. policy to serve all demand for enrichment services. Then, in 1974, it became evident that existing enrichment capacity was fully committed. The federal government announced that it would not accept enrichment contracts for any new reactors; in essence, the order books were closed until such time as a commitment was made to construct new capacity in this country. Unfortunately, this investment decision became tangled in a longstanding debate over private vs. public development of new enrichment facilities. As yet the debate has not been resolved, although the proposed fiscal 1978 budget does provide funds for a new government plant.

Apparently, the change in U.S. policy caught many consumers by surprise, and the removal of the U.S. as a "reliable" supplier sent a shock wave through the international nuclear industry. Several European countries were already involved in enrichment schemes; the U.S. action gave them greater impetus. More important, nations other than the participants in European projects sensed an insecurity in the supply of enrichment service.

International Effects: Nuclear Proliferation. Why should these concerns about "dependence" have become a subject of international discussion? Nations face situations of this type from time to time. A host of measures are available to deal with them — commercial policies, international treaties, spurring of domestic supplies, suppression of domestic demands, stockpiles.

Here we come to the aspects of uranium that make it "special." It can be argued that the fears of dependence are acting as a spur to the spread throughout the world of material suitable for nuclear weapons, for in a period when supplies of reactor fuel appeared to be secure, there was relatively small commercial incentive for nations outside the U.S. and Europe to develop their own enrichment capacity. Soon after the U.S. policy change on enrichment, however, a number of arrangements were made (for example, a German deal with Brazil) which involve

the transfer of enrichment technology into new areas of the world. In addition, the concern about the supply of uranium and enrichment has been used as a justification for fuel reprocessing and the use of mixed-oxide fuel. Finally, concern that the resource base may be inadequate for a substantial light-water-reactor economy leads to a push for the breeder reactor, which in turn requires the construction of reprocessing plants and a fuel cycle based on plutonium. In short, the problem of "dependence," which was muted when the U.S. stood ready to accept new orders for reactor fuel, now becomes more acute. The problem internationally is that fears of dependence may be pushing the world into a plutonium economy at a faster rate than necessary, leading to increased problems of nuclear proliferation.

It should immediately be said that the products of the nuclear fuel cycle are not the only contributors to the proliferation problem. Research reactors, coupled with clandestine reprocessing plants, small in size, can be a source of weapons material. Thus there is no simple, decisive action that will eliminate the threat of proliferation; and there are only partial gains to be made by limiting some of the sources of weapons material and reducing some of the incentives for weapons possession. It is beyond the scope of this article to discuss and analyze the overall risks and benefits of the plutonium economy, or of the nuclear industry as a whole. Rather, the issue to be addressed here is whether the access to weapons material is being increased by the dependence problem. After all, whatever one's view of the plutonium economy, its advent is a sufficiently serious matter that we should avoid being pushed into it under pressure that might well be avoided. If we are to live with the plutonium economy and its leavings for centuries to come, it seems worthwhile to devote serious attention to the preparation of the technologies and human institutions that will manage it. Few would argue that our current systems of international controls and safeguards are yet adequate to the task.

International Effects: Market Disruptions. A second point where the dependence problem creates international spillovers is in the competition for access to uranium reserves: some forms of competition for long-term supplies may actually constrain the uranium market so that it cannot perform the function of balancing supplies and demands, now and in the future. Such actions may thus *contribute* to the very political instability which causes a good deal of the dependence problem in the first place. There are growing indications that major consuming nations are attempting to gain control over the resources of particular supplier countries. This might be achieved by bilateral treaties or protocols, by special barter arrangements for other components of the fuel cycle, or by other special country-to-country concession or marketing arrangements.

Several advantages can be gained if such special rights are obtained, of course. The purchasing country may gain control over the resources, and thereby guarantee a long-term supply for its own reactors. Moreover, if the purchasing country is a reactor vendor, it may be possible to use such special rights to back up package deals for "reactors with fuel" and thus gain advantages in markets for nuclear technology. In return for these advantages to the purchasing country, the uranium-exporting country may be offered a host of inducements — economic, technical, and diplomatic.

There are at least three problems with nation-to-nation economic and political barter in the place of the arms-length dealings characteristic of a conventional commodity market. First, there is the matter of economic efficiency. Under such arrangements, low-cost resources may sit untapped while high-cost reserves are exploited. This might happen, for example, if low-cost ores in an exporting nation are held in reserve for the very-long-term needs of an importing customer (say, by bilateral treaty), while other importer nations must exploit higher-cost resources elsewhere.

Second, if supply from an area is closely tied to the state of relations between two particular nations, then the vulnerability of supply to political events may be increased over what it would be in a market context. So far as the uranium-exporting nation is concerned, an exclusive concession may be rendered unacceptable by conflicts between exporter and buyer over unrelated issues, or by changes in internal politics. In a period when relations are disrupted, supply may also be interrupted (or at least made less reliable) to third-party customers.

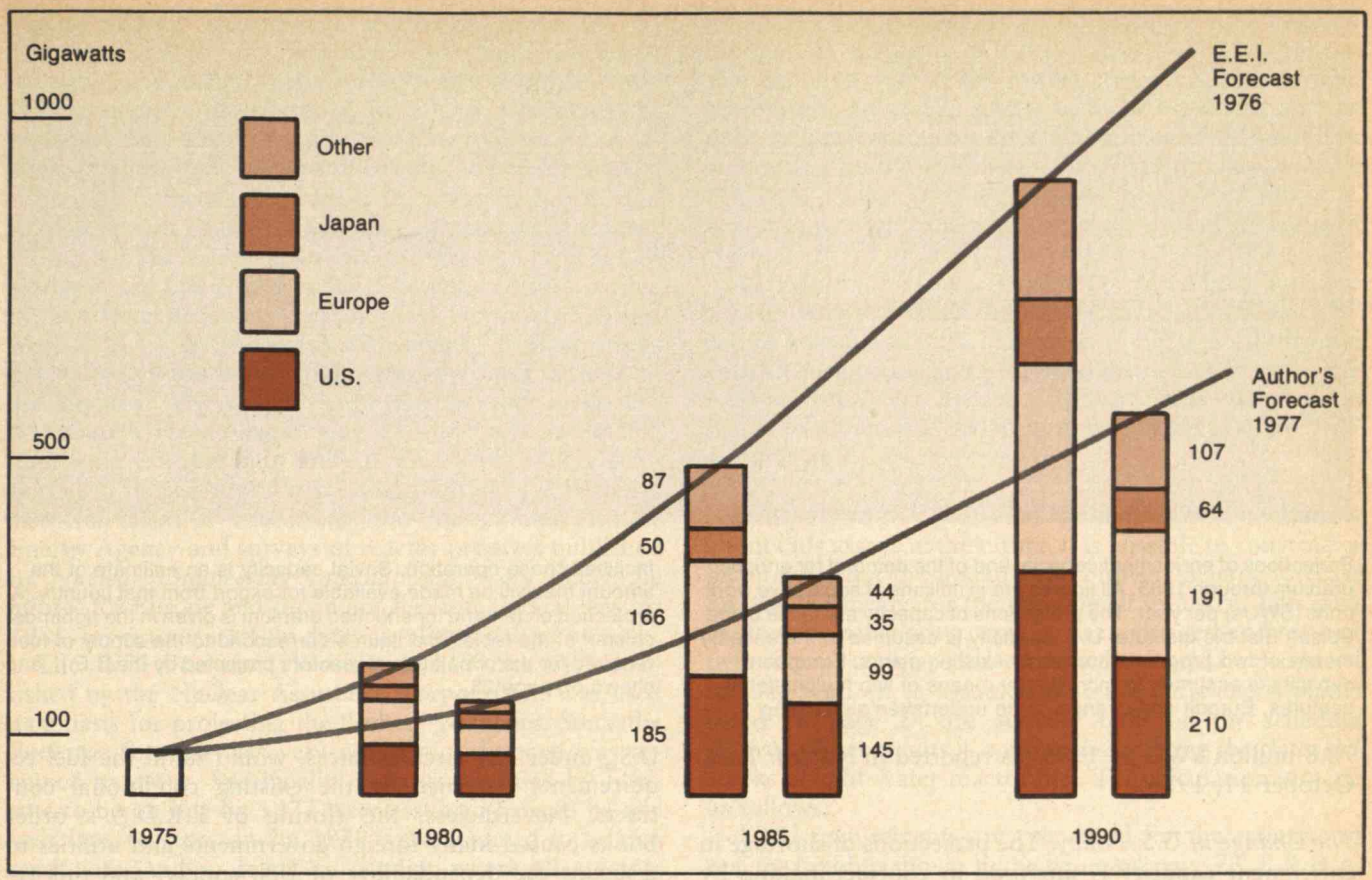
Finally, and perhaps most important, if major consuming nations can tie up resources through bilateral deals, then the access to supply becomes less certain for the consumer who does not (or cannot) make such an arrangement. That is, when most resources are politically committed to a few customers, then the margin of material coming on the open market may become relatively small and intermittent. In such a situation the outsider will be less confident of his ability to secure supplies, and thus less willing to depend on the market. His natural reaction will be to seek bilateral deals of his own, or to lessen his dependence on imported uranium by moving more quickly to the breeder reactor or to fuel reprocessing.

In short, when confidence in the market mechanism fades, then the actions taken to secure supplies often tend to make the situation even worse. Even the U.S. cannot avoid this issue; though we have substantial domestic resources of uranium, we have no export restrictions on that substance, and several foreign countries are exploring for new resources in this country. If exports threaten to become significant in comparison to future U.S. needs, and if the U.S. restricts exports to protect its own long-term independence (as Canada has done), then we can hardly expect others not to seek a similar level of control over at least *some* reserves. In the worst circumstance, the commodity market in uranium could disappear. Some nations would be more secure, no doubt, but the dependence concerns of others would be very much heightened.

Thus there are many aspects to the dependence problem, and actions taken because of concern about this issue can have significant effects on the international community. We must better understand how serious the problem is. If it is less serious than it appears, that information may itself be of help. If necessary, however, we must search for policy measures that may lessen the difficulty.

"Dependence" in the Medium Term

By the end of 1975, nuclear generating capacity worldwide had grown to approximately 80 gigawatts-electric (GWe). In the wake of the oil crisis, nuclear power appeared even more attractive than before, and predictions of accelerated growth were common. The higher of the two forecasts in the figure opposite is representative of the outlook within the nuclear industry at the time — specifically, early in 1976. The data are from an influen-



Two projections of growth in the nuclear power industry. For each of the years 1980, 1985, and 1990, the bar at the left is the prediction of the Edison Electric Institute, published in *Nuclear Fuels Supply*. The bar at the right is the author's updated prediction, based on conditions in 1977, and taken from several sources, as described in the text.

tial study by the Edison Electric Institute (E.E.I.), *Nuclear Fuels Supply* (March, 1976), and they are entirely consistent with figures quoted by the U.S. government as of late 1975 and early 1976.

Also shown in the figure is a set of estimates based on conditions in early 1977; the downward revision in expectations for the nuclear industry has been significant. More will be said later about these revised estimates; but first it is important to point out that the E.E.I. demand estimates (and others like them) served as the basis for alarm about the ability of the fuel supply system to keep up, and helped foster the idea that dependence on international sources was risky. In the U.S., for example, concern was expressed about an impending shortage of enrichment capacity in 1983, and about uranium mining and milling capacity as well. The table on page 24 shows the E.E.I. projection of the planned worldwide expansion in enrichment facilities to 1985. The capacity of an enrichment plant is given in terms of units of work that can be put into the separation of U^{235} from U^{238} — the so-called "separative work units" (SWU). The projected change in existing U.S. capacity is to be accomplished by the implementation of two programs: a "Cascade Improvement Program" (CIP), which increases capacity solely through process refinements without raising power consumption; and a "Cascade Uprating Program" (CUP), which increases capacity still further, but at the expense of additional power consumption. CIP represents an increase of roughly 5.8 million SWU per year; CUP brings an additional 4.7 million; the result is a total U.S. enrichment capacity of 27.7 million SWU per year. CIP and CUP are to be completed by 1985, and the table takes no account of events beyond that.

European capacity, which presently consists of two small plants in the U.K. and France, is assumed in the table to grow by the construction of two enrichment ventures. Urenco-Centec, a joint venture of the German, Dutch, and British governments, will employ a new centrifuge technology. It is assumed to reach 1 million SWU per year by 1980, and 2 million by 1982. Eurodif, an organization sponsored chiefly by France with the participation of Belgium, Italy, Spain, and Iran, will use the traditional method: gaseous diffusion. Its capacity is assumed to reach 1 million SWU per year by 1979 and grow to a full output of 10.7 million SWU per year by the mid-1980s. The total capacity of the Soviet Union and other communist countries is not known with accuracy, but it is estimated that approximately 3 million SWU per year will be committed by the Soviets to the export market. In addition to these firm enrichment plans there are a number of proposals around the world. A list of these, drawn from the E.E.I. study and reports in *Nucleonics Week* and *Nuclear News*, is shown on page 26.

The E.E.I. reactor projection presented on this page translates into demand for enrichment as shown in the rightmost column of the table on page 24. (Note that communist countries are excluded.) This comparison of supply with demand shows demand for enrichment services outstripping the expected capacity by sometime in 1983 — a prediction consistent with recent market forecasts by Eurodif which assess a total non-communist enrichment demand of 56.4 million SWU by 1985, and of

	Capacity						Total demand
	U.S.	France and U.K	Eurodif	Urenco	U.S.S.R. export	Total	
1976	16.1	.6	—	—	.8	17.5	*10.9*
1977	17.1	.6	—	—	1.6	19.3	*12.4*
1978	18.4	.6	—	.2	2.5	21.7	*15.3*
1979	21.6	.6	1.5	.5	3.0	27.2	*21.3*
1980	24.6	.6	4.5	1.0	3.0	33.7	*25.7*
1981	25.3	.5	7.5	1.4	3.0	37.7	*29.8*
1982	25.3	.3	10.2	2.0	3.0	40.8	*33.6*
1983	25.5	—	10.7	2.0	3.0	41.2	*40.2*
1984	26.7	—	10.7	2.0	3.0	42.4	*48.4*
1985	27.7	—	10.7	2.0	3.0	43.4	*54.5*

Projections of enrichment capacity and of the demand for enriched uranium through 1985. All figures are in millions of separative work units (SWUs) per year. The projections of capacity are those of the Edison Electric Institute. U.S. capacity is assumed to increase by means of two programs applied to existing plants. European capacity is assumed to increase by means of two multinational ventures, Eurodif and Urenco, to be undertaken as existing facilities cease operation. Soviet capacity is an estimate of the amount that will be made available for export from that country. A projection of demand for enriched uranium is given in the rightmost column of the table. The figures correspond to the supply of fuel required for the population of reactors projected by the E.E.I., and shown on page 23.

78.8 million SWU by 1988 (as reported in *Nuclear Fuel,* October 11, 1976).

The Change in U.S. Policy. The projections of shortage in enrichment capacity is mirrored in contract-making by the U.S. Energy Research and Development Administration. E.R.D.A. has three types of contracts with both domestic and foreign customers:

— *Requirements contracts,* whereby E.R.D.A. agrees to supply all the enrichment services of a specific reactor, whenever it comes on line, up to a cumulative separative work ceiling over the life of the contract (usually 30 years). This type of open-ended contract was offered only until 1973.

— *Long-term, fixed-commitment contracts,* whereby the customer agrees to take (and E.R.D.A. agrees to supply) fixed quantities of separative work over a ten-year contract period, and to provide a rolling ten-year advance notice for additional requirements.

— *Conditional contracts,* which E.R.D.A. was to convert to regular long-term, fixed commitment contracts if the use of plutonium as fuel in light-water reactors were approved by the Nuclear Regulatory Commission.

In early 1974, the requirements and fixed-commitment contracts held by E.R.D.A., plus the expressions of interest by various consumers, yielded a total demand far exceeding the capacity of the enrichment plants the U.S. had taken a firm decision to build. This circumstance led, in July of 1974, to the "closing of the books" for further orders placed with E.R.D.A. Some customers were given only the newly instituted "conditional" contracts, which could be honored if enrichment capacity were freed up by the adoption of recycling. In effect, the only way a new customer could now gain access to E.R.D.A. enrichment services was (and is) by purchasing an existing contract or some portion of it — a process known as "assignment."

This situation developed against the background described earlier. It had been U.S. government policy to provide an unlimited supply of enrichment services to the non-communist world; and indeed, on August 7, 1974, President Nixon guaranteed foreign countries that the U.S., under any circumstances, would fulfill the fuel requirements governed by the existing conditional contracts. Nevertheless, the closing of E.R.D.A.'s order books caused many foreign governments and utilities to discount the dependability of U.S. supply, and this reevaluation provided the incentive to search for alternative arrangements that would offset the dependence on the U.S. Accordingly, U.S. officials concluded that new enrichment capacity must be commissioned as quickly as possible if the U.S. was to maintain its world leadership in enrichment services and nonproliferation initiatives. In June, 1975, the Ford Administration proposed that the next increment of enrichment beyond the ongoing CIP and CUP programs be developed by private corporations rather than by the U.S. government, but the enabling legislation for the private-sector scheme failed to pass the Congress. As of now, plans have been set in motion to build an 8.75 million SWU extension to E.R.D.A.'s Portsmouth plant (see the table on page 26), and President Carter's newly announced energy program renews this commitment. Other than this one plant expansion, the U.S. policy with regard to enrichment remains to be sorted out by the new administration and the Congress.

The concerns of recent years have also extended beyond the adequacy of enrichment supply to the adequacy of uranium supply in its unenriched, natural state. The E.E.I. forecast of U_3O_8 demand implies a doubling of current mining and milling capacity by 1979 — a task that the E.E.I. study judged to be attainable (see the table on page 21). But the forecast requires *another* doubling by 1983, and yet another doubling within five to six years after that! The problem of such a rapid capacity expansion in the mining and milling industry — exacerbated by political uncertainties — has created the fear that uranium feed will be lacking.

Lower Forecasts. The paragraphs above describe the outlook in late 1975 and early 1976. Since then, circumstances have changed significantly. The predictions of reactor growth, it now turns out, were overstated, due to a number of factors. The national prestige associated with

"going nuclear" lead to wishful forecasts and made nations reluctant to revise estimates downward. Increased licensing and environmental delays and rising nuclear-plant costs have also been significant. Most important, however, the recent recession and energy-price increases have dampened the growth of electric power demand.

In order to form a more accurate picture of the next ten to fifteen years, I have prepared an updated set of reactor forecasts. They are shown in the figure on page 23 alongside the E.E.I. predictions. The updated forecast for the U.S. takes account of recent E.R.D.A. projections and work at M.I.T. by Joskow and Rozanski. The figures very likely are still too high; reactor start-up dates in the U.S. are slipping. The estimates for Europe and Japan are based on a recent assessment by the Organization for Economic Co-operation and Development, which is reported in its *World Energy Outlook* (1977). Advantage also was taken of forecasts by the International Atomic Energy Agency and surveys of reactor progress published by *Nuclear Engineering International.* Very likely the figures for Europe and Japan are also too high, at least to 1985, for reactor start-up dates are slipping there as well.

The 1975 Fuel-trac "Worldwide MW Survey," published by the Nuclear Assurance Corporation, was used as a basis for projecting the "other" countries. Since the Fuel-trac forecast was very optimistic, slippage was assumed to occur. Specifically, reactors assumed by Fuel-trac to be on line by 1977 were assumed here to be one year late, reactors due in 1979 were assumed to be two years late, and so forth, to a point where all reactors scheduled for 1983 and after are a total of four years late.

Though I believe that, overall, even the lower forecast of the figure on page 23 is still optimistic, the precise numbers are not crucial to the discussion. What is important is the general magnitude of the shift: downward even from very recent assessments of the nuclear picture. Rough estimates of that shift have significant implications for uranium dependence, for conditions have been created that may allow the buildup of large stockpiles of light-water-reactor fuel, and the way this opportunity is handled has important implications both for new enrichment ventures and for the stability of the uranium industry.

Tails Assays. In order to talk about the quantities of fuel that may be involved, it is necessary to introduce a few technical details about the operation of enrichment facilities. As the enriched material is produced, there results a waste stream with some residual U^{235} left within it. This waste product is called the enrichment "tails." The amount of U^{235} in the tails can be controlled: additional cycles through the separation process will produce 3-per-cent enriched product in greater quantity, and the assay of U^{235} in the tails will be reduced. But more and more work (SWUs) per unit of product is required as this process proceeds. Thus, for any particular amount of reactor fuel (3-per-cent enriched product) there is a tradeoff between the quantity of uranium feed (U_3O_8) and the quantity of enrichment services (SWUs) required.

Today, the E.R.D.A. enrichment plants are running at a 0.25 per cent tails assay (that is, the waste stream contains 0.25 per cent U^{235}). If the tails assay were dropped to 0.20 per cent, then for the same quantity of 3-per-cent enriched fuel the U_3O_8 feed requirement would go down by 10 per cent. On the other hand, the SWU input would go up by 16 per cent. Now, for any given price for enrichment (dollars per SWU) and price for raw material (dollars per kilogram of U_3O_8) there is some tails assay that produces fuel at the lowest cost. At current prices, the optimal tails assay turns out to be below the current operating rate: probably somewhere around 0.20 per cent tails rather than the current 0.25 per cent. However, the E.R.D.A. operation is influenced by the fact that E.R.D.A. is working down a large, government-owned stockpile of U_3O_8.

As noted in the figure on page 20, enrichment tails are not thrown away. Tails containing, say, 0.25 per cent U^{235} can be stored and, at a later date, re-introduced into the enrichment process and processed further, perhaps to the 0.20 per cent level. In fact, E.R.D.A. holds considerable stocks of uranium in the form of enrichment tails at 0.25 per cent and above.

Fuel Supply in the 1980s. By making some assumptions about tails assays in the future, it is possible to construct a picture of what the updated (and lower) reactor forecast on page 23 means for the enrichment industry. This may be done by calculating, area by area, the demand for fuel over time as compared to the fuel that *could* be produced in that year. (It is assumed that the enrichment plants listed on page 24 are actually built on the schedule shown.) What results is a number signifying the *potential* stocks of light-water-reactor fuel. The calculation is made as follows:

— SWU requirements are calculated for the estimate of reactor buildup shown in the figure on page 23. E.R.D.A. is assumed to operate at a 0.25 per cent tails assay, as at present. New European capacity is assumed to operate at 0.20 per cent from the beginning. Little is known about the U.S.S.R. exports, but they are evaluated as if they were produced at a 0.25 per cent tails assay.

— An estimate is made of shipments of light-water-reactor fuel from E.R.D.A. plants based on fixed-commitment contracts and the realization of requirements contracts as estimated by E.R.D.A. as of November 30, 1976. These shipments are subtracted from the gross demands of U.S. utilities, Europe, Japan, and "other" nations.

— Based on E.R.D.A. estimates, it is assumed that 16.1 million SWU are devoted to preparing material for domestic military and research programs through 1988.

— E.R.D.A. enrichment plants are assumed to run at full capacity, and any deficit in relation to contracted shipments becomes a demand on the E.R.D.A. stockpile. Excess production augments the E.R.D.A. stockpile.

— All Urenco and Eurodif production is credited to Europe, as are all exports from the U.S.S.R.

— A reactor capacity factor of 0.70 is assumed throughout; that is, after an early shakedown period all reactors are assumed to operate, on average, at 70 per cent of their rated electrical capacity.

Such a calculation predicts that U.S. utilities have ordered more fuel than they will use over the next decade or more. E.R.D.A. continues to add to stocks of enriched material well into the 1980s. Europe also is predicted to have excess supply — all the way to 1988. The rest of the non-communist world is in a similar situation as late as 1984. The crossover date when current demand exceeds enrichment capacity advances to 1987 from the 1983 crossover shown in the table on page 24.

In short, if enrichment capacity augments as predicted, stocks of light-water-reactor fuel can build up around the

	Technology	Participants	Expected size (million SWU per year)	Date
Planned:				
ERDA	Diffusion	U.S.	8.75	Mid-1980s
Urenco	Centrifuge	U.K/Holland/F.R.G.	8	Late 1980s
PNC	Centrifuge	Japan	5	?
STEAG	Nozzle	F.R.G.	?	?
UCOR	Nozzle	South Africa	5	Mid-1980s
Potential:				
Australia	Centrifuge	Australia/Japan	?	?
Canadif	Diffusion	Canada/France	?	?
Brinco	Diffusion/Centrifuge	Canada	8	1983
Brazil	Nozzle	Brazil/F.R.G.	1 to 2	?
Saskatchewan	Centrifuge	Canada	?	?
Coredif	Diffusion	Western Europe	9	1986
Centar	Centrifuge	U.S.	1 to 3	?
Garret	Centrifuge	U.S.	1 to 3	?
Exxon	Centrifuge	U.S.	1 to 3	?
UEA	Diffusion	U.S.	9	?

Prospective changes in the world's catalog of uranium enrichment plants. The E.R.D.A. facility named in the first line of the list is an addition to the existing facility at Portsmouth, Ohio. The Urenco facility (second line of the list) is an addition to the Urenco facility included in the table on page 24. This addition will be built if the first facility proves successful.

world. The figure on page 18 shows the extent of the buildup that could occur under the assumptions made here. Two different measures of stockpile size are shown. One is the total number of SWUs that have gone into the production of material in the stocks. (Stocks as of January 1, 1977 are credited as if they had been produced at a tails assay of 0.25 per cent.) The other is the number of years of operation of one-GWe reactors that could be run, at a capacity factor of 0.70, with the fuel in the stock. Since the fuel enrichment actually varies slightly above and below 3 per cent depending upon the reactor type, it is assumed in preparing the prediction that the reactor population is two-thirds pressurized water reactors and one-third boiling water reactors — roughly the mix today. (At a tails assay of 0.25 per cent, each 100,000 SWU will provide 1 GWe-year of fuel, two-thirds of which is to be used in PWRs and one-third of which is to be used in BWRs.)

As the figure indicates, E.R.D.A. already held a stockpile of 21.5 million SWU as of the end of 1976. The Japanese also hold a stockpile: approximately 8.9 million SWU, created by an advance sale from the U.S. to Japan in 1973, and stored in the U.S. It is due to be depleted on a fixed schedule to meet a portion of contracted requirements. Here it is assumed to be drawn down at a uniform rate over ten years. Current stocks elsewhere are not known and are assumed to be zero.

The potential stock buildup is striking. The countries in the "other" category build up stocks slowly over time. By the mid-1980s they hold stocks equal to roughly two years of mid-1980s demand. The Japanese hold E.R.D.A. contracts that follow our forecast of their reactor growth very closely, though this is masked in the stock figures by the influence of material from the advance sale. In Europe, large stocks are attainable under the assumptions made here. The stocks in the mid-1980s could build to over four years' worth of total demand for reactor fuel.

The stock buildup in U.S. utilities is modest — never more than a year's consumption. The stocks held by E.R.D.A. on the other hand, become very large — rising as high as 650 GWe-years in the mid-1980s.

Complicating Factors. Of course, the projection shown on page 18 is only a forecast of what is "attainable"; there are several reasons why it may not come about. After all, several assumptions lie behind the calculation, and most of these involve decisions that have yet to be made. First, it is unlikely that the *demand* for Soviet enrichment will reach the 3 million SWU per year assumed to be available for export. Second, either unavoidably or by conscious decision, the Urenco or Eurodif plants could be delayed. Either of these events would lower the stocks credited to Europe. On the other hand, several of the prospective plants listed above are well on the way to construction. Some combination of these plants might yield a considerable increase in total capacity outside the U.S.

Several matters could influence the E.R.D.A. stocks as well. E.R.D.A. could decide to recycle tails rather than process raw U_3O_8. Under some operating schemes, this could involve a reduction of as much as 8 million SWU, or roughly 80 GWe reactor years. Moreover, E.R.D.A. could lower the tails assay of the enrichment system as a whole, say to 0.20 per cent, which also could cut the stockpile size. On the other hand, a plant the size of the planned Portsmouth expansion, if built on the current schedule (2.1 million SWU in 1984, growing to 8.75 million SWU in 1986), would add another 350 GWe-reactor-years of fuel to U.S. stocks by 1988.

On another point, there are several factors that could shift the proportions of the total U.S. domestic stockpile between E.R.D.A. and the utilities. It is assumed here that E.R.D.A. deliveries follow the anticipated schedule of requirements contracts. If the slippage in reactor construction involves many power plants holding requirements contracts, the deliveries will be reduced and stocks will

grow at E.R.D.A. instead of in the consumer's hands. It also is assumed here that deliveries follow the specified schedule of reactors under fixed-commitment contracts, assuming a capacity factor of 0.70. In fact, many fixed-commitment contracts involve an implied capacity factor above 0.70; some are as high as 0.75 or 0.80. These high capacity factors are unlikely to be attained; even the 0.70 used here seems optimistic, considering recent reactor operating history. However, if fuel deliveries are actually made on the contracted schedule, then a portion of the stocks now credited to E.R.D.A. actually will build up in the hands of the utilities. E.R.D.A. could then call another "open season" whereby adjustments are allowed in the fixed-commitment contracts, and this would have the effect of shifting the stock-holding burden back onto E.R.D.A. Of course, the degree to which this happens depends on how badly the U.S. utilities, or foreign buyers, want to get out from under the burden of holding the stocks themselves.

Then there is the question of U.S. government policy about building and holding stockpiles. The E.R.D.A. stockpile will be expensive to create, and the funds must be provided from the federal budget. It is quite possible that E.R.D.A. facilities would be run at less than full capacity (this has happened in the past) or that programs to increase the electrical power inputs to the enrichment plants would be postponed. Or, if many enrichment contracts were cancelled or postponed, E.R.D.A. might run into limitations on uranium feed, which is delivered to E.R.D.A. by the customer a few months before the enrichment is to be done. E.R.D.A. would then face a choice of purchasing feed directly or changing the amount of feed that enrichment customers are required to provide.

Even with all these complexities, the basic situation is clear. The world now has the opportunity to create sizable stockpiles of light-water reactor fuel. Whether in fact we shall do so depends on decisions by the U.S. government, the countries of Urenco and Eurodif, and the major consumer countries and their utilities. The problem is not inadequacy of supply, but whether or not to purposefully create surplus over the next decade.

The choice will have tremendous consequences for the domestic uranium mining and milling industry. At present, E.R.D.A. is managing the enrichment plants under a "split tails" policy: though the plants are operating at a tails assay of 0.25 per cent, E.R.D.A. is transacting with customers as if the tails assay were 0.20 per cent. This implies that buyers of enriched uranium are not being required to deliver the full amount of uranium feed needed by the enrichment plants; E.R.D.A. is making up the balance of the U_3O_8 demand from the government's U_3O_8 stockpile.

The split tails policy serves to convert government stocks to a more highly processed form. It is presumed that the policy will continue until at least 1982, when the U_3O_8 stocks will have been depleted. Given this presumption, and the operating conditions for enrichment plants specified earlier in this article, the effect of the stockpiling decision on the domestic U_3O_8 industry can be approximated: If E.R.D.A. were to decide to satisfy only demand for reactor fuel as it occurs, with no provision for building a stockpile, the demand on uranium mines and mills in 1982 would be 22,500 metric tons of U_3O_8; E.R.D.A. would have to supply an additional 1,900 metric tons from the government stockpile. On the other hand, if E.R.D.A. were to use to excess SWU capacity (above that needed to satisfy current domestic demands and foreign contracts) to build a stockpile of light-water-reactor fuel, the demand on the mining and milling sector in 1982 would be 30,500 metric tons of U_3O_8; E.R.D.A. would have to supply an additional 2,600 metric tons of U_3O_8 from the government stockpile.

It is evident that considerable uncertainty is created by the peculiar linkage of the uranium-mining industry to an enrichment and stockpiling policy that can (and probably will) change over time. To quote a representative of the French Atomic Energy Agency, ". . . it is now more important for the uranium mining industry to know what the long-term stockpiling policy of utilities or governments will be than to know if it is the low or the high estimate of installed reactor capacity which will actually be achieved in a given year."

Pros and Cons of Stockpiles

Given the stockpiles shown on page 18 as a possible scenario, it is interesting to contemplate the implications of continuing on the path now being followed — that is, the path of building and operating the enrichment capacity shown in the table on page 24.

Calculations of Cost. The first question concerns the cost of building the stockpile. A very crude calculation can show at least the order of magnitude of the numbers. The evaluation can be based on the following set of simplifying assumptions:

— The stockpile is taken to comprise 3-per-cent enriched uranium, and there is taken to be no stockpile of unenriched U_3O_8.

— The cost of the stockpile is to be compared with a "no stockpile" option whereby the total stock held within and outside the U.S. is assumed to remain at its 1976 level.

— The cost of material for the stockpile is to include the marginal cost of uranium and enrichment services. Enrichment is assumed to cost $75 per SWU, and the associated uranium feed (roughly 1.56 kilograms per SWU at 0.25 per cent tails) is assumed to cost $100 per kilogram. The cost of adding one GWe-reactor-year of fuel to the stockpile is $23.1 million. This cost (in 1976 dollars) is assumed constant over the period of the calculation.

This set of assumptions allows the calculation of the cost per year through 1986, when it hits its peak. As of that year, the stockpile has some terminal value: it will continue to serve some security function, or it could be drawn down in the longer-term future, displacing other costs. In this simple calculation no attempt is made to estimate that value.

Now the results: the cost of building the worldwide stockpile starts out at about $1.9 billion per year in 1977 and grows to approximately $4.3 billion in 1981. It then falls to zero by 1986. At 8 per cent interest, the present value in 1977 of the cost of building the stockpile to 1986 is around $20 billion.

Another approach is to calculate the carrying charges on a strategic stock. For example, under our assumptions a one-GWe reactor needs fuel costing $23.1 million each year. At 8 per cent interest, the carrying charge on a one-year stock is $1.8 million, or 0.3 mills per kilowatt-hour (KwH) for each year's worth of stock held in reserve. These figures may be compared with a rough estimate of the total fuel cycle cost (3 to 5 mills per KwH) or of the total cost of power at busbar (20 to 28 mills per KwH).

These are very rough numbers. In a more careful esti-

A long-term projection of the world's uranium requirements. The top part of the table is a rough forecast of the size of the nuclear industry through the end of this century. The nature of the calculation is explained in the text. The bottom part of the table shows the corresponding demand for uranium from the mining and milling industry — in other words, the demand for enrichment-plant feedstock. Two measures of this demand are given: The first line shows the cumulative consumption required to support the reactor population from year to year. The second line assumes that as each reactor comes on-line, sufficient fuel is set aside to support it over a thirty-year lifetime.

	1976	1980	1985	1990	1995	2000
Installed Capacity (GWe)						
U.S.	43	66	145	210	308	453
Other	35	100	178	362	531	782
Total	78	166	323	572	389	1,235
Uranium Requirements (10^3 MT U_3O_8)						
No recycle, 0.20% tails						
Cumulative used	28	128	368	794	1,459	2,414
Cumulative commitments	463	947	1,827	3,142	4,582	6,708

mate, account should be taken of the fact that the E.R.D.A. U_3O_8 stock already exists, and thus that part of the mining and milling cost charged to the stockpile has, in fact, already been paid. Also, one would need to worry more about the likely patterns of change in the price of uranium as depletion occurs. But whatever the precise numbers, the costs of a stockpile are seen to be large in absolute terms, but relatively small in relation to the total costs of nuclear power. The issue to be raised is whether the gains are worth the burden.

Benefits of a Stockpile. One way to look at the benefits of the stockpile is to construct some indicator of the level of "independence" that it might provide on a worldwide basis. For example, one may calculate how many years of growing demand the stockpile can cover in the event new enrichment capacity is delayed. Thus, if no enrichment facilities were built beyond those listed on page 24, the stockpile would not be drawn down to the 1976 level until 1992. Alternatively, if the Urenco and Eurodif plants were each delayed by two years, and no additional capacity were built elsewhere, the stocks built in the 1970s and early 1980s would still allow world demand to be covered through 1990. One can also look at the quantity of fuel available to serve the needs of areas that have no indigenous enrichment capacity. Under the scenario shown on page 18, the worldwide stocks in 1985 are over 25 times the fuel demand by "other" countries in that year, and over 15 times the combined demand of "other" countries plus Japan.

Clearly, if stocks of this size were available, there should be less pressure in a number of countries to close the fuel cycle within their own borders. For with a cushion of reactor fuel available, either in domestic stocks or in some secure external stockpile, the security advantages that are claimed for domestic enrichment capacity or fuel reprocessing are much reduced.

The choice to stockpile would also have an effect on net demand for uranium, and this in turn would have important effects on its supply and price. Consider that a cutback in the anticipated need for new mines would probably retard exploration. The world would then learn less about the extent of uranium resources. On the other hand, a decision to build enrichment facilities on schedule and to accumulate a stockpile would maintain exploration, as well as the growth of the mining and milling industry. A related effect might nevertheless be higher prices, if uranium demand in combination with stockpiling were to put too much pressure on mining and milling.

Stockpile Management. A stock of uranium hanging over the market will serve to create uncertainty about future demand and price. The worry is that the stock might enter the market at any time, thus suppressing uranium prices. The risks of investment in mining and milling would be raised as a result. Accordingly, the form of ownership and management of the stock is crucial. Broadly speaking, there are three possibilities. First, the stockpile could be dispersed in the hands of many utilities or nations. If they were to forbid any further export of enriched uranium from the countries that purchased it, the stockpile would increase security without threat of disruption of markets. If, on the other hand, the holders of the stockpile were to allow trading, there *would* be a threat that stockpiles might come on the market. In such a case the uncertainty in the price of reactor fuel would be great, and this doubtless would have significant effects on the expansion of uranium supply and enrichment capacity.

The second possibility is that the stockpile could be held by a single nation — as would be the case, for example, if importers took only the uranium needed on a current basis and the United States correspondingly built the stockpile alone. The nation holding the stockpile would have great power over the market, of course; and that nation might also gain bargaining and negotiation advantages on international issues such as proliferation. In an article in *Foreign Affairs* (July, 1976), Senator Abraham Ribicoff has suggested that the U.S. follow such a policy, and seek to use our current enrichment monopoly to gain leverage on proliferation issues.

As a final alternative, the stockpile could be held under international auspices. This also is a situation that could yield a wide variety of results. An international body could use the manipulation of a stockpile to establish commodity prices over considerable periods of time. (In fact, managers could hardly avoid having *some* effect on price, even if their charter forbade them to exert such leverage.) It could use the stockpile to help form a uranium cartel, or to prevent one. It could protect the interests of small, "dependent" nations through special-access arrangements; this could ameliorate the fears of dependence cited at the outset. Further, it could provide fuel from internationally-held stocks to substitute for resources foregone when a nation does not pursue fuel reprocessing.

Thus there are myriad possibilities for management. The costs are great, but so may be the benefits. The issue is far from settled. It will be greatly influenced by decisions in the coming year about E.R.D.A. enrichment pro-

cedures; by European planning for Urenco and Eurodif; and by intentions in various nations to purchase enriched uranium from the Soviet Union.

Implications For Longer-Term Adequacy

The recent revision in expectations about reactor growth also has a significant effect on perceptions of the long-run adequacy of uranium resources. The table opposite presents a rough calculation of the uranium requirements for the light-water reactor industry to the year 2000. The reactor forecast developed earlier in this article is used through 1990. After that time, nuclear capacity is assumed to grow at 8 per cent per year. The reactor capacity factor is assumed to be 0.70, as before. A tails assay of 0.20 is used throughout, for it is likely that all uranium will be processed at least to this extent before the end of the century, even if only gaseous diffusion plants are in use. The uranium requirements are stated in terms of the cumulative consumption of resources up to any year, and also in terms of the total commitment of resources if reserves are set aside to meet requirements over each reactor's full 30-year life.

The table shows cumulative demand rising to 368 thousand metric tons of U_3O_8 by 1985, and 2,414 thousand metric tons in the year 2000. Meanwhile, cumulative commitments reach 6,708 thousand metric tons. Now these projected requirements may be reduced by new fuel processing technologies: a laser-enrichment method, if it can be made to work, would allow processing to zero per cent tails. Accordingly, on the assumption that all previous tails at 0.20 per cent are further processed by laser devices, the cumulative demand by the end of the century totals only 1,762 thousand metric tons, and the cumulative commitments total 4,897 thousand metric tons, a drop of approximately 27 per cent. If reprocessing and mixed-oxide fuel were introduced, these requirements would drop by an additional 15 to 20 per cent.

The question, of course, is what to compare these numbers with. The table on page 21 shows a world total of 4,340 thousand metric tons of U_3O_8, taking account of reasonably assured and estimated additional resources at $30 per pound of U_3O_8. Even considering the fact that some probability distribution must be attached to these estimates, there is reason to consider this as a conservative estimate of the resources available:

— The addition of possible and speculative reserves for the U.S. as estimated by E.R.D.A. would add another 1,600 thousand metric tons, for a world total of roughly 6,000 thousand metric tons.

— The U.S. and Canada have been extensively explored. Many other areas of the world have not. In these two countries, the "estimated additional" resources are two to three times the "reasonably assured." If a similar pattern were to hold for the rest of the world (as it should with more exploration) the total would rise to 7,000 to 8,000 thousand tons.

— The figures shown on page 21 are for a cutoff level of $30 per pound forward cost. Little is known about potential reserves at 2 to 3 times this cost level, yet these higher costs could be sustained by a light-water-reactor economy.

Naturally, no one knows what the true resource figures are, though our knowledge is growing rapidly. And it is well to remember that the availability of resources of uranium is not synonymous with its supply, for supply implies both the decision to exploit the resources and the development of the mines, mills, and supporting industries to do so. Still, even these rough estimates allow some interesting observations. Under the assumptions in the table opposite, only in 1995 do cumulative *commitments* reach what is likely to be a very conservative estimate of resources. Cumulative *consumption* would not reach this level until the next century. If laser enrichment proves feasible, and if reprocessing ultimately is adopted, then these resources seem adequate to reach well into the next century.

In short, even under pessimistic assumptions, it should be 20 years before the resource constraint really begins to bind, and there is a good chance that the world will not face resource constraints until after the year 2000. As a result, there is a breathing space — albeit a short one, considering the time lags in developing a major new high-technology industry — before breeders or fuel reprocessing are required to sustain a growing nuclear contribution to energy supply. The U.S. government has decided to take advantage of this opportunity, and has postponed the commercialization of the breeder reactor and the operation of associated reprocessing facilities. Prudence requires that we use this time well, and mount an urgent effort to find a socially preferable alternative to the plutonium cycle. We also must give high priority to efforts to better understand worldwide uranium resources and supply, so that better estimates can be made of what real stringencies may be ahead.

All nuclear nations face the same world resource situation, of course, but it is much easier for the U.S. to delay the race to the breeder than it is for other major nuclear nations. We are sitting on the world's largest proved reserves of uranium; Europe and Japan must depend on the world market. Thus the hope that other nations may take a delaying action similar to ours depends critically on the present security — and the expected future security — of the supply of conventional light-water-reactor fuel. Measures to lower the fear of uranium "dependence" — including the careful use of fuel stockpiles — must become a critical component of U.S. policy if the desired benefits of our non-proliferation initiatives are to be realized.

Author's Note

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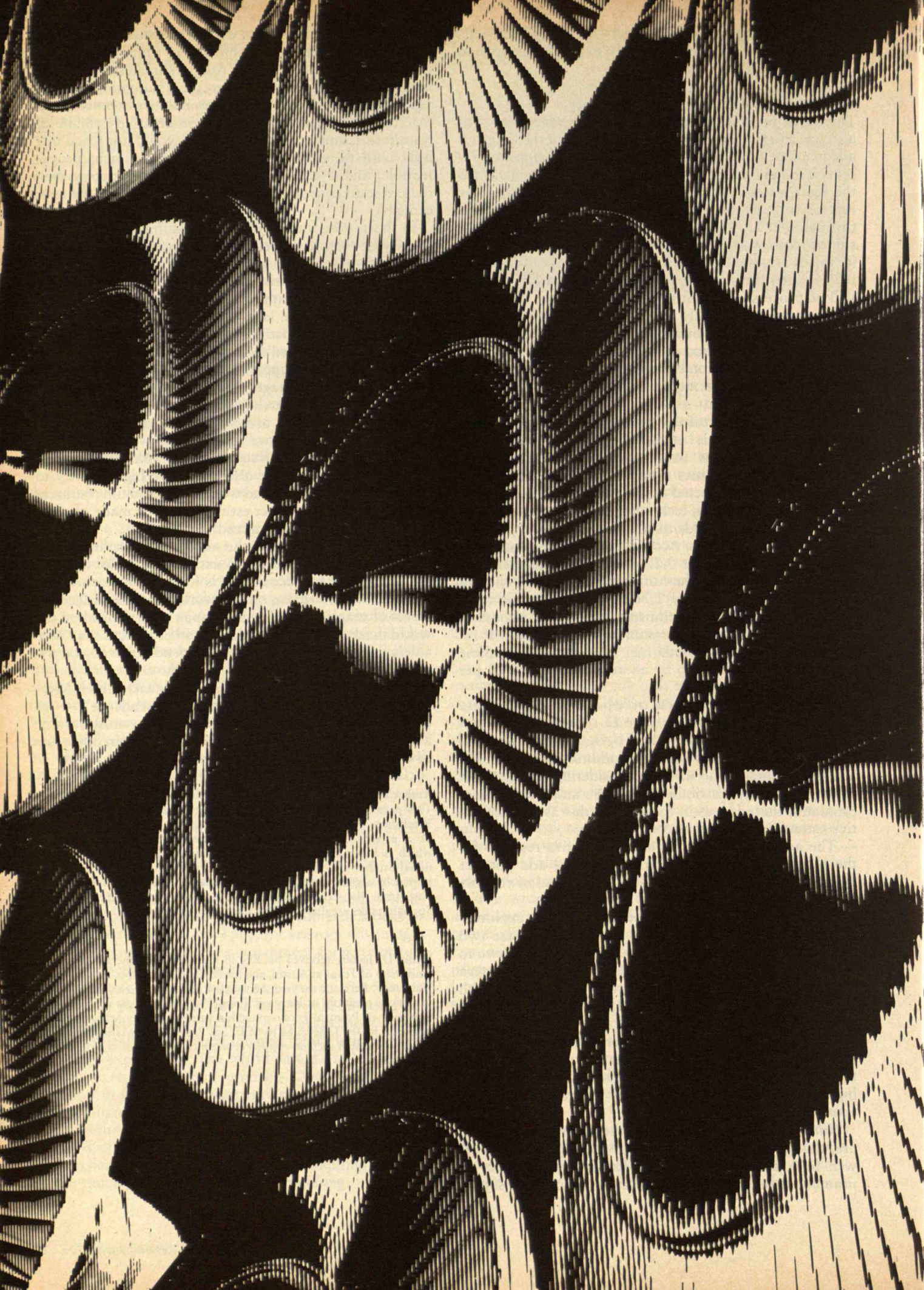

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Far from hindering economic growth, a policy of strict energy conservation proves an exceedingly wise investment.

Energy Conservation and a Healthy Economy

It is only too well known that we are exhausting our finite store of fuels at an alarming rate, especially the gaseous and liquid forms. It's also painfully clear that we are investing more and more for new energy supplies and obtaining less and less for our money. International fuel prices have increased much faster than the prices of other commodities because of this scarcity of petroleum and natural gas and the high cost of new energy sources. Most indications are that this gap will keep widening for many decades to come. Fortunately, is is quite certain that we can re-optimize each energy-consuming task to achieve the same result at equal or lower cost, and use far less energy. In this paper we will show the firm technical and economic bases that underlie this seemingly bold assertion. We will show that there is an enormous opportunity for reduced energy consumption per unit of product in every sector of the economy; and if we do not take advantage of this opportunity, our economic well-being and security will be endangered.

Re-optimizing energy end-uses will, of course, require long-term commitments involving significant restructuring of all sectors of society. This restructuring cannot happen automatically, because of many institutional barriers and many distortions of the free market system introduced by past decisions. But these barriers and distortions are not insurmountable. They can be largely eliminated if we attack them with a comprehensive energy policy, such as the accelerated conservation policy we propose.

Technical Room for Conservation

The laws of thermodynamics give us a most convincing technical basis for estimating the possibilities for energy conservation. Specifically, the second law of thermodynamics affords a yardstick that is universally applicable to all fuels and all processes. The second law implies that energy has a "quality" about it and that this quality can only be degraded as energy is consumed to perform useful tasks. The "available work" in a system is a quantity that takes into account both the quality and the quantity of energy (*see "The Potential for Fuel Conservation" by Marc H. Ross and Robert H. Williams, February, 1977, pages 48-57*). This "available work" concept has been used in several studies to measure the efficiencies of various energy-using processes in our society, as a function of the task to be performed, rather than the particular device used to perform that task. Some of the efficiencies estimated in these studies are:

— Residential and commercial space heating: 6 per cent,
— Residential and commercial water heating: 3 per cent,
— Air conditioning and refrigeration: 5 per cent,
— Automobile propulsion: 10 per cent,
— Steel production: 21 per cent,
— Petroleum refining: 9 per cent,
— Cement manufacturing: 10 per cent,
— Paper production: less than 1 per cent.

The total amount of fuel used in these applications is about 60 per cent of all U.S. energy consumption. The average efficiency of utilization, obtained by weighting each efficiency by the amount of fuel used for the purpose, is only 8.3 per cent. Moreover, the figure of about 8 per cent is believed to be fairly representative of the overall energy effectiveness throughout the economy. The 10 per cent efficiency given for automobiles actually overstates their performance considerably, since this calculation takes into account only the efficiency of converting fuel energy to tractive effort at the driving wheels. It is extremely difficult to specify auto efficiencies precisely because of various non-technical factors affecting the vehicle design, such as add-on hardware to enhance convenience, safety, comfort, etc.

We're not suggesting that energy efficiency will ever approach 100 per cent for real devices or processes, even in the remote future. We wish to emphasize, however, that the present low values of efficiencies indicate the enormous opportunity for energy savings and that no fundamental scientific barriers exist to prevent substantial improvements in energy end-use effectiveness. Even a modest improvement, for example from 8.3 to 9.3 per cent efficiency, represents a saving of almost 10 "Quads" per year at the 1975 consumption level (where a Quad equals 10^{15} Btu's). This is the energy equivalent of 4.6 million barrels of petroleum per day.

Some analyses mistakenly associate large energy savings with reduced economic activity. In 1972, for example, an analysis for the Chase Manhattan Bank stated almost fatalistically that "analysis of the uses of energy reveals little scope for major saving. The great bulk of the energy is utilized for essential purposes, . . . Conceivably, the use of energy for such recreational purposes as vaca-

More efficient turbine rotors such as these produced at Westinghouse will enable significant improvements in the efficiencies of turbines, with no economic penalties. So little research has been done on improving the energy efficiency of industrial processes, say the authors, that a huge untapped potential for energy savings may exist. (Illustration: Judy Richland)

tion travel and the viewing of television might be reduced — but not without widespread economic and political repercussions. There are some minor uses of energy that could be regarded as strictly nonessential — but their elimination would not permit any significant saving."

More correctly, a report by the Energy and Environment Division of the Lawrence Berkeley Laboratories answered that "more informed studies of energy use contradict this analysis. Especially misleading is the subjective phrase *essential purposes,* which obscures the whole question of efficiency. Careful analysis of energy use has revealed an enormous potential for energy conservation. The most recent forecasts from the Energy Research and Development Administration suggest that U.S. energy needs in the 1990s could be 20 to 40 per cent below what was previously expected, as higher energy prices and new end-use technologies help Americans squeeze more economic and personal well-being from every Btu."

The process known as cogeneration offers an impressive example of the energy savings obtainable using only current technology. Cogeneration — the combined production of electricity and industrial process steam — offers an opportunity for conservation because steam for industrial processes is produced at relatively low pressure and temperature and, hence, does not make good use of the high-temperature heat available from fuel combustion. The common practice of producing low-pressure process steam in a fuel-fired boiler is therefore thermodynamically inefficient. The practice can be made much more effective by first producing high-pressure steam in a boiler, then expanding this steam through a turbine to generate electricity and then exhausting the steam at the appropriate pressure level needed for the desired process.

The electricity thus produced is obtained at an additional fuel consumption rate less than half that achieved by the most efficient central station power plant. Since over 40 per cent of industrial energy — or about 16 per cent of all the nation's energy — is used in the form of process steam, the potential savings are enormous. In West Germany, cogeneration accounts for over 18 per cent of electrical needs, compared to only about 5 per cent in the U.S. A recent study by Thermo Electron Corp. for the Federal Energy Administration revealed that in just three industries — papermaking, chemicals, and petroleum refining — there exists the opportunity to produce over 34 per cent of all the nation's electricity by means of cogeneration and waste heat recovery.

While long-term dramatic improvements in end-use efficiencies can probably be made throughout the economy there will be a significant capital cost involved, unlike the case with many of the simple measures already implemented in response to rising energy prices. Such conservation actions, involving the trade-off of energy cost savings against initial capital costs, deserve the most careful attention in formulating a new U.S. energy policy.

Skyrocketing Supply Costs

To understand just how economically sound conservation measures really are, we can compare capital requirements for various supply and conservation measures.

On the supply side, diminishing fossil fuel resources have necessitated the investment of enormous amounts of capital per unit of energy production capacity. True, Middle East reserves are still readily accessible. However, most new petroleum or natural gas production areas —such as the U.S. outer continental shelf, North Sea, Alaska, etc. — require anywhere from $10,000 to $15,000 for each barrel per day of equivalent fuel energy provided. This translates into a capital demand of about $4.5 to $6.8 billion for every Quad per year of energy delivered. Synthetic gas and oil obtained from coal will be even more capital intensive, probably requiring more than $10 billion per annual Quad.

New coal supplies are still obtainable at a capital cost of $1.5 billion to $2.0 billion per annual Quad. However, coal mining, processing, and combustion produce serious environmental and safety problems which may ultimately limit the rate of coal consumption, or at least cause increases in the cost of supply. Moreover, coal cannot be as flexibly used as oil and gas. The industrial sector could undoubtedly substitute more coal to produce steam, for example, but increasing our reliance upon coal will depend mainly upon its greater use by electric utilities or the development of economical gasification methods.

Electricity as a form of energy requires a much higher capital investment. For every Quad per year of delivered electricity, the capital investment in facilities for fuel supply, generation, transmission, and distribution will range from $45 billion for coal-based systems to about 1.5 times as much for nuclear generation. We cannot directly compare electricity costs with those for coal and petroleum fuel resources, because electricity has far greater flexibility of usage than does raw fuel. Even so, the capital cost of coal-based electricity is about $15 billion per annual Quad of coal converted to electricity, or more than eight times the capital cost of raw coal supply, itself.

Despite its high capital cost, electricity occupies a

unique and vital place in the spectrum of energy forms. Many tasks exist that can be performed only by energy of the highest thermodynamic grade, such as electricity. So electricity is an essential part of a balanced energy supply system. Electricity should be recognized, however, as having both special properties and high capital intensity, and therefore should not be used as a convenience fuel, as for home heating.

The enormous and growing capital required to develop new energy supplies could injure the entire economy. According to even highly optimistic projections of economic growth and capital formation, the U.S. economy is unlikely to produce more than $2.7 trillion for all purposes over the next decade. Assuming that the long-standing ratio between business and residential investments prevails, about $1.8 trillion will be available for all business investments for both new capacity and replacement purposes. A New York Stock Exchange report estimated that, of that capital, the energy supply industry would require more than $800 billion.

It is an alarming prospect that we might have to allocate almost half of all business capital to energy supply investments alone. In the recent past, the energy industry has consumed only about one-fourth of total U.S. business capital, and even this fraction had created growing stresses in the capital markets. Unless this trend is reversed, we will soon be devoting so much of our scarce capital resources to energy production that other business needs will suffer a severe lack of investment funds.

A Bargain in Conservation

In contrast to the rising expenditures needed to develop diminishing fuel reserves, conservation can be put to effective use with substantially smaller capital commitments.

For example, for only a modest investment we could reap large improvements in the energy efficiency of the common window air conditioner. Data published by the Federal Council on Science and Technology showed that three commercially available room air conditioners with exactly the same 5,000-Btu-per-hour cooling capacity had the following initial costs and energy consumptions:

— $120 for a 4.58 Btu/watt-hour unit;
— $140 for a 5.80 Btu/watt-hour unit;
— $165 for a 8.70 Btu/watt-hour unit.

As you can see, by investing only $45 in additional first cost — 38 per cent more — one can obtain an efficiency improvement of 89 per cent.

Since the air conditioner is likely to be used only 500 hours per year, or about 6 per cent of the time, the energy saving will be 258 kilowatt-hours per year. However, its usage is likely to coincide with the period of highest summer electrical demand. Hence, the $45 increment for conservation can be viewed as a direct substitution for more than one-half kilowatt of expensive utility system peak generation and distribution capacity, having a value of at least $200.

Unfortunately, user benefits do not reflect the same degree of advantage indicated by the capital cost comparison. In fact, the consumer would save only about $18 per year for 500 hours of use, yielding a gross payback of about four years. Even this moderately attractive return can be illusory when the ultimate consumer does not participate in the initial purchase decision, for instance if he lives in a rental apartment or housing equipped by the builder rather than by the owner.

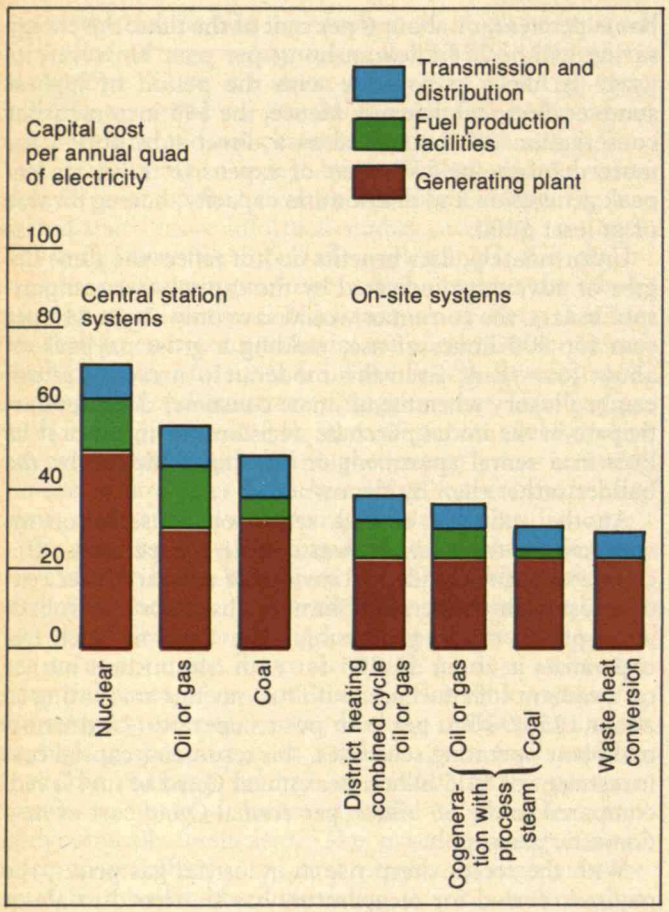
Another example of high return on conservation investment is the case of waste heat recuperators. Recuperators can provide fuel savings of at least 25 per cent on most high-temperature furnaces used for controlled-atmosphere metal processing. The cost of such recuperators is about $1,300 for each combustion burner on a radiant tube furnace, with fuel savings amounting to about 125,000 Btu per hour per recuperator. Under normal plant operating schedules, this represents capital cost investment of $1.5 billion per annual Quad of fuel saved, compared to the $6 billion per annual Quad cost of new domestic gas supply.

With the recent sharp rise in industrial gas prices, the payback period for recuperators has shortened to about three to four years, a range that is still only marginally attractive to most industrial firms whose capital budgets can barely cover essential or "main-stream" business investment needs.

The generation of electricity from waste heat also represents an excellent investment opportunity. A recent engineering study conducted for a major cement manufacturer revealed the opportunity for producing 4,700 kilowatts of electricity by capturing waste heat from the exhaust of the company's cement kilns using a steam-electric bottoming cycle system. The cost of the system was $2.7 million.

If that 4,700 kilowatts were to come half from a new coal plant and half from a new nuclear plant a capital investment of more than $7 million would be required for fuel supply facilities, generating apparatus, and transmission and distribution equipment. In terms of energy capital effectiveness, the waste heat recovery system costs less

Capital costs are significantly less to construct on-site power generation systems at industrial facilities than to build large central station systems.



than $25 billion per annual Quad of electricity, or less than half that of the average investment required for new coal and nuclear utility capacity.

It is noteworthy that in this particular case the conservation equipment was not installed, and the cement plant continues to purchase its electricity at 2.5 cents per kilowatt-hour. Allowing for operation and maintenance of the steam-electric bottoming cycle, the savings would have been $775,000 per year; i.e., the energy conservation investment would be recovered in about 3.5 years. Since this payback did not meet the company's requirements for discretionary investments, the proposal was rejected. As a result, the failure to implement this one conservation measure in one cement plant causes a continuing loss to the nation of 180 barrels per day equivalent petroleum. In general, capital investments for on-site generation of electricity by various schemes are smaller than those for central power stations, as shown in the chart at the left.

These few examples have only scratched the surface of conservation investment possibilities for industry. We have identified numerous examples of energy conservation investments in the steel, aluminum, oil refining, paper, chemical and other industries that significantly outperform corresponding investments in new energy supplies. In other sectors of the economy cost effective opportunities might include:

— Substitution of diesel engines for gasoline engines in light trucks, which would require less capital per unit of fuel saved than does new petroleum supply capacity.

— Weight reduction in automobiles through material substitution, which can actually decrease total capital cost.

Reducing passenger space is also cost-effective, but this type of energy conservation involves changing life-style and consumer tastes rather than improving technical efficiency, which is the focus of this discussion. It is important to clarify the distinction between these two different kinds of conservation, and to dispel the popular misconception that conservation is equivalent to belt-tightening. Such actions, usually taken in response to immediate crises, tend to obscure the real and lasting benefits of conservation through improved end-use effectiveness.

Some Barriers to Conservation

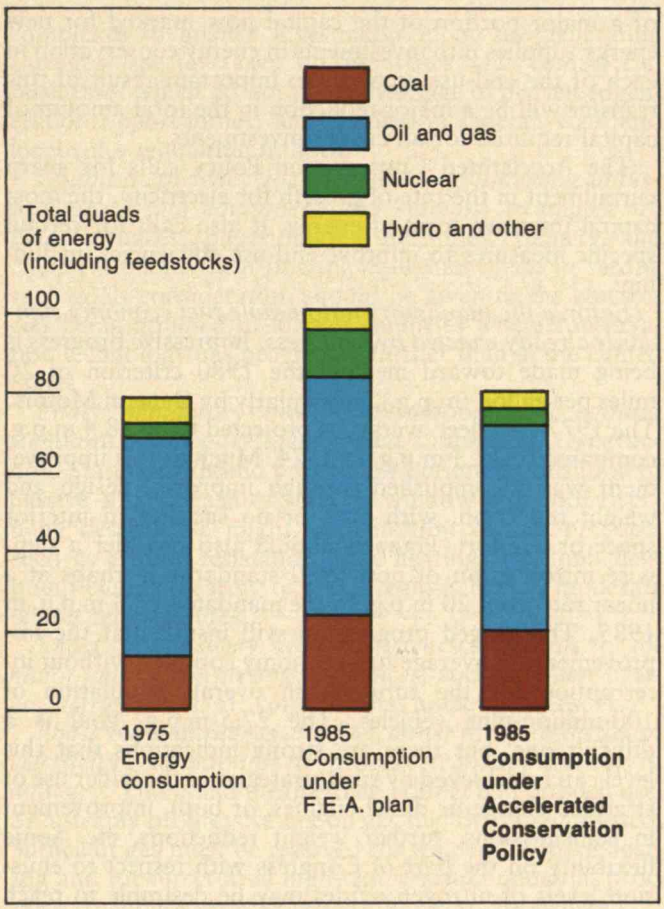
Because of their economic attractiveness, one might expect capital investments in conservation to proceed at a faster rate in the industrial than in the residential or other sectors of the economy. After all, in industry energy users are likely to have a greater awareness of first-cost versus operating-cost tradeoffs. However, industry has not significantly outpaced other sectors in improving its energy efficiency. Where industrial conservation investments have been made, the decision has often been influenced by factors other than simple economics; for example, the threat of outright curtailment of production due to fuel interruption.

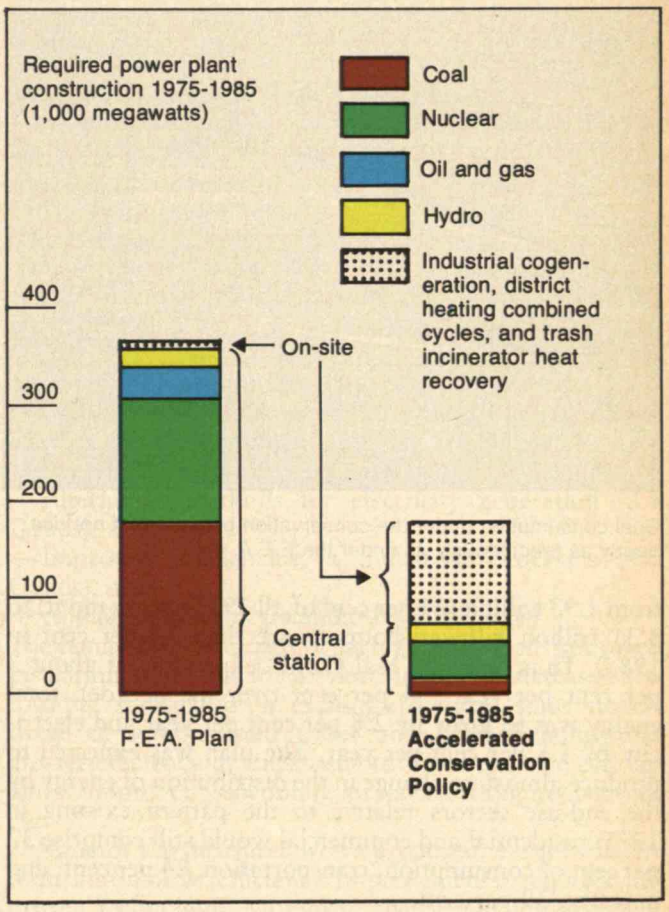
We've identified several reasons behind industry's reluctance to invest in energy-efficient equipment:

— Most energy-user companies must maintain conservative debt-to-equity ratios because of uncertainty about the future availability and cost of financing. Conservation investments, therefore, do not usually command high priority in the competition for limited capital funds.

The authors' Accelerated Conservation Policy would essentially bring energy demand after a decade to the same level as the 1975 consumption, at the same time allowing a normal economic growth. This demand is smaller than that forecast in a Federal Energy Administration plan which relies primarily on prices.

A conservation policy would drastically reduce the required utility investment in central station electrical generation capacity, from $391 billion to $91 billion. An additional $61 billion increment of power generation capacity would be spent for generation capacity at the site of use.





These funds must first be reserved for essential mainstream business purposes, such as tooling new products and expansion of capacity to meet market conditions.

— Criteria for investment payback are more stringent for manufacturing companies than for regulated utilities whose risks are lower.

— The pricing of industrial electricity and fuel is largely based on average, rather than incremental costs of supply.

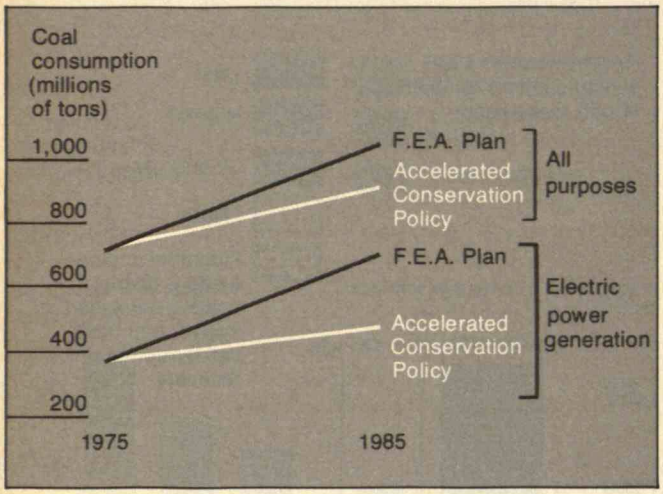
— These factors tend to create a major distortion in the deployment of scarce capital resources to achieve the optimum balance between investments in new energy supply and in energy conservation.

A Plan for Accelerated Energy Conservation

A new government policy stressing energy conservation could produce major changes in our energy usage patterns in a relatively short time and without impairing economic expansion. By comparing energy demand estimates, with and without an accelerated conservation approach, one can really see the important differences that might be anticipated during the next decade.

For our scenario of life *without* accelerated conservation, let us examine a 1975 report by the Federal Energy Administration (F.E.A.) entitled, "National Energy Outlook." In its ten-year forecast for U.S. energy production and usage the F.E.A. predicted that higher energy prices alone could cut 1985 consumption from an unconstrained demand level of 123 Quads to about 107 Quads. Demand would be restricted further, to about 101 Quads, by some additional conservation measures which were not specified.

Under the F.E.A. plan, electrification was to increase



Coal consumption under the conservation policy would not rise nearly as precipitously as under the F.E.A. plan.

from 1.93 trillion (24 per cent of all 1975 energy input) to 3.35 trillion kilowatt-hours (more than 34 per cent in 1985). Thus, with the real G.N.P. expanding at about 3 per cent per year (34 per cent over the decade), total energy was to grow by 2.8 per cent per year and electricity by 5.5 per cent per year. The plan was expected to produce almost no change in the distribution of energy by the end-use sectors relative to the pattern existing in 1975: residential and commercial would still comprise 37 per cent of consumption; transportation, 24 per cent; and industry, 39 per cent.

The F.E.A. projected a shift in energy resources, with coal rising from 18 per cent in 1975 to 22 per cent in 1985, nuclear energy rising from 3 per cent to almost 10 per cent (accounting for over one-fourth of electricity generation), and oil and gas declining from 74 per cent to 63 per cent (the major reduction occurring in electric utility consumption of these fuels).

To provide a framework for evaluating these forecasts we have devised an alternative plan which stresses conservation measures. Based upon the same growth in real G.N.P. as assumed in the F.E.A. plan — approximately 3 per cent per year — the alternative approach postulates no substantial social changes or curtailment of living standards. This "Accelerated Conservation Policy" is by no means the only plan that might be considered, but it illustrates some of the benefits realizable by more effective energy end-use.

A key element of the conservation policy is the transfer of a major portion of the capital now marked for new energy supplies into investments in energy conservation in each of the end-use sectors. An important result of this transfer will be a major reduction in the total amount of capital required for all energy investments.

The Accelerated Conservation Policy calls for sharp curtailment in the rate of growth for electricity, the most capital intensive form of energy. It also calls for certain specific measures to improve end-use efficiencies, including:

Enforce the mandatory automobile fuel economy standards already enacted by Congress. Impressive progress is being made toward meeting the 1980 criterion of 20 miles per gallon (m.p.g.), particularly by General Motors. The 1977 GM fleet average is projected to be 18.4 m.p.g. compared to 12.3 m.p.g. in 1974. Much of this improvement was accomplished through improved design and weight reduction, with little or no sacrifice in interior space or comfort. Planners should also consider a stepwise introduction of post-1980 standards, perhaps at a linear rate from 20 m.p.g. to the mandated 27.5 m.p.g. in 1985. This staged progression will insure that the improvements in average fuel economy continue without interruption for the turnover in overall population of 100-million-plus vehicles. The 27.5-m.p.g. goal is a difficult one, but there are strong indications that this level can be achieved by such strategies as the wider use of stratified charge or diesel engines, or both, improvement in transmissions, further weight reductions, etc. Some flexibility on the part of Congress with respect to emission levels of nitrogen oxides may be desirable to reach the optimum balance between fuel economy and exhaust pollutants.

Construct alternative electric generation capacity in lieu of 103,000 megawatts (Mw) of planned central station capacity. This alternative capacity would include cogeneration of electricity with industrial process steam (64,000 Mw); generation by district plants producing both electricity and space heating for buildings (32,000 Mw); and burning trash to generate electricity (7,000 Mw). Together, these electricity sources would contribute 24.5 per cent of all U.S. electricity. To stimulate this substantial shift away from central station utilities to the far more efficient systems identified above, several actions will be required, such as mandatory rules for purchase of surplus industrial electricity by utilities; a restructuring of backup or demand charges originally designed by utilities to discourage on-site generation; provision of direct government loans to industries and apartment or commercial

complexes to finance investments in on-site generating capacity; special taxes on industries and commercial businesses which do not take advantage of proven cogeneration opportunities; and changes in federal, state and local rules regulating utilities.

Establish efficiency goals for all energy-intensive industrial processing equipment and systems; examples are blast furnaces, paper-making machines, refinery and chemical plants, heat-treating equipment, etc. In setting such goals consideration should be given to the efficiencies being attained in foreign countries where conservation technology has progressed further than in the United States.

Enact mandatory heating, insulation, and lighting standards for new residential and commercial construction. Standards should provide for optimum utilization of passive solar measures such as window and roof overhang design. We might also prohibit certain practices such as electric resistance space heating, and limit heat pump electric heating to those regions having moderate winter temperatures.

Enact progressively stricter efficiency standards for all major energy consuming appliances, such as water heaters, refrigerators, air conditioners, home furnaces, etc.

Phase out natural gas as a fuel, either for central station electricity generation or for process steam applications in industry. This could mean either a direct ban on such use, or a steeply progressive tax on gas fuel that is so misused. Sufficient gas must be reserved for residential space heating and for direct-fired high-temperature industrial processes to avoid excessive growth in electricity demand.

Provide direct government loans and other economic incentives to finance the retrofitting of houses with conservation equipment, including insulation, storm windows, improved furnaces, and other cost-effective systems. This program should be continued until every structure in the nation has been modified to an extent commensurate with the capital cost of incremental new energy supply. These measures probably won't be completed until well beyond 1985, and our projections assumed less than one Quad of savings per year.

Collectively, these and several less important actions would reduce energy consumption over the next decade to 80 Quads per year, a saving of 21 Quads relative to the F.E.A. plan. In effect, energy growth can be almost halted over the ten-year span while economic activity can still expand by 3 per cent per year. Moreover, the costly electrical sector would increase to only 2.53 trillion Kwh, a growth rate of 2.8 per cent per year relative to 1975. The fraction of total energy converted to electricity, 29 per cent, is higher than in 1975, but still well below the 34 per cent figure projected by the F.E.A. plan.

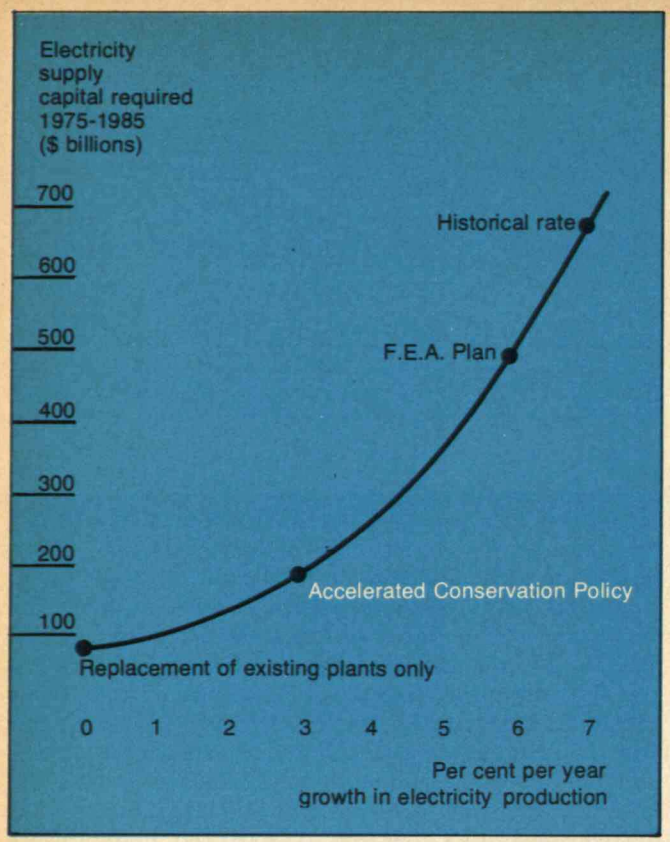
In the Accelerated Conservation Policy, distribution of energy by end-use sector differs from that of the F.E.A. plan, with transportation accounting for only 20 per cent, and industry rising slightly to 42 per cent. Sources of energy would change somewhat (*see page 35*) with nuclear fuel contributing only 7 per cent instead of 10 per cent of all energy. The fraction for oil and gas is about the same for both plans — 63 per cent — but the contribution of coal rises from 22 per cent to 24 per cent under the accelerated conservation alternative.

Major contributions to the 21 Quads of total energy saved under the conservation policy are due to:
— Automobile fuel economy standards (5.6 Quads),
— Alternative methods for electricity generation (2.9 Quads),
— Improved efficiencies in industrial processes (4.5 Quads), and
— Appliance efficiency standards (2.5 Quads).
The remaining 5.5 Quads of savings result from improved insulation standards for all new buildings, increased retrofitting of insulation in existing structures, some modest usage of solar-assisted water and space heating, and greater efficiency in trucks due to wider use of diesel engines, improved scheduling practices, drag reductions, etc.

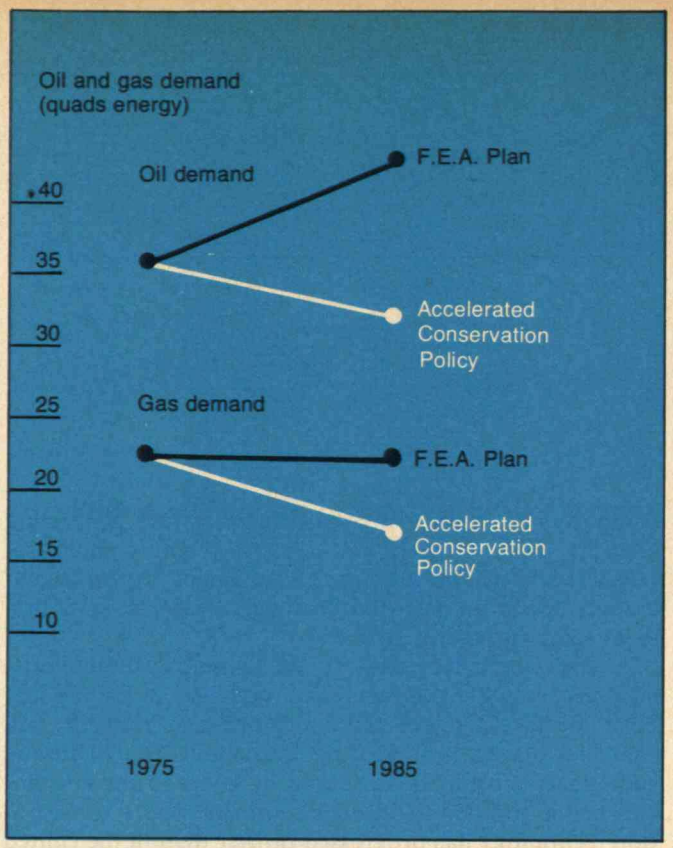
None of the measures we've proposed, except for far-term automobile efficiency improvements, requires unproven technology. Moreover, the overall improvement represents only a modest aggregate gain in the absolute efficiency of devices and processes. In fact, under our policy the average efficiency of energy utilization increases to 10.9 per cent — only 2.6 percentage points over the 8.3 per cent we mentioned earlier. Approximately one-third of this gain is attributable to automobile fuel economy improvements alone.

What Cost Conservation?

The most striking difference between the Accelerated Conservation Policy and the F.E.A. plan is the amount of capital needed to implement these alternative programs. Over the 1975-to-1985 decade the F.E.A. plan would require $570 billion for energy supply and $78 billion for energy conservation, for a total investment of $648 billion. In sharp contrast, the Accelerated Conservation Policy would require $61 billion for supply and $157 billion for conservation, for a total of only $218 billion — *less*



Because of the slower growth of electrical demand, capital investment requirements for generation capacity, transmission and distribution, and fuel production facilities will be far less.



The greatest dividends of an Accelerated Conservation Policy occur because of sharply reduced oil and gas demand. In effect, accelerated conservation measures become the second most important energy source in 1985.

than half the F.E.A. capital requirements.

These enormous capital savings are due in large part to sharply lower central station electric generating capacity. Less generating capacity investment is needed, not only because of reduced total electrical demand, but also because of the lower cost of alternative combined-cycle generating equipment, such as cogeneration. As you can see on page 35 and following, the conservation policy will thus result in significant savings on nuclear and fossil generating plant construction, and on coal, oil and gas consumption.

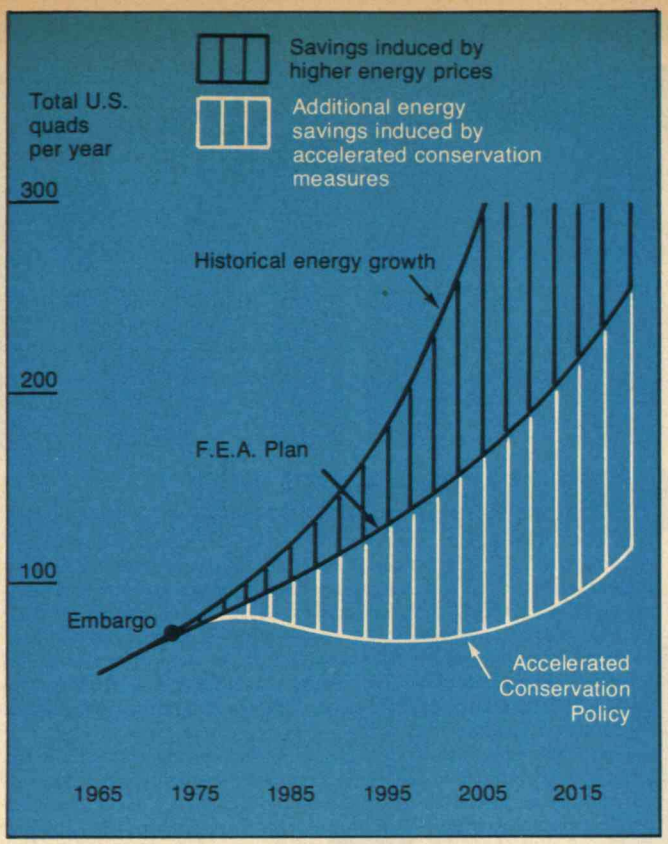
Savings on petroleum consumption will have a dramatic effect on imports. Accelerated conservation policies produce a net surplus or reserve of 4.5 Quads per year of natural gas by the end of the decade as is shown by comparisons of F.E.A. projections of maximum natural gas supply with our calculations of demand under a conservation policy. Required petroleum imports will be only 5.3 Quads or 2.4 million barrels per day — about one-third the present level of imports. Even if natural gas price controls were continued, the Accelerated Conservation Policy would curtail usage enough to almost exactly balance F.E.A.'s domestic supply forecast of 17.9 Quads for price-controlled supply. In contrast, the previous F.E.A. plan with complete price deregulation achieves zero imports in natural gas, but still requires the import of about 6 million barrels per day of petroleum — over 13 Quads.

There are clear and compelling economic advantages to the nation for conserving more energy. Before this can occur, however, we must resolve the differences between two different sets of economic assessments that ultimately determine how we balance energy conservation. The problem is that investment decisions on conservation are generally made by a completely different group than that responsible for capital investments in energy supply. These two groups operate under substantially different ground rules for return-on-investment and access to capital markets. For example, the return-on-investment for energy conserving equipment required by energy users in industry is much higher than that for electricity plants achieved by regulated utilities, and the debt-to-equity ratio of manufacturing industries is much lower than that of utilities. Thus, it is totally unrealistic to suppose that the so-called "free market" approach will produce an optimal allocation of the nation's scarce capital resources among energy supply and conservation options.

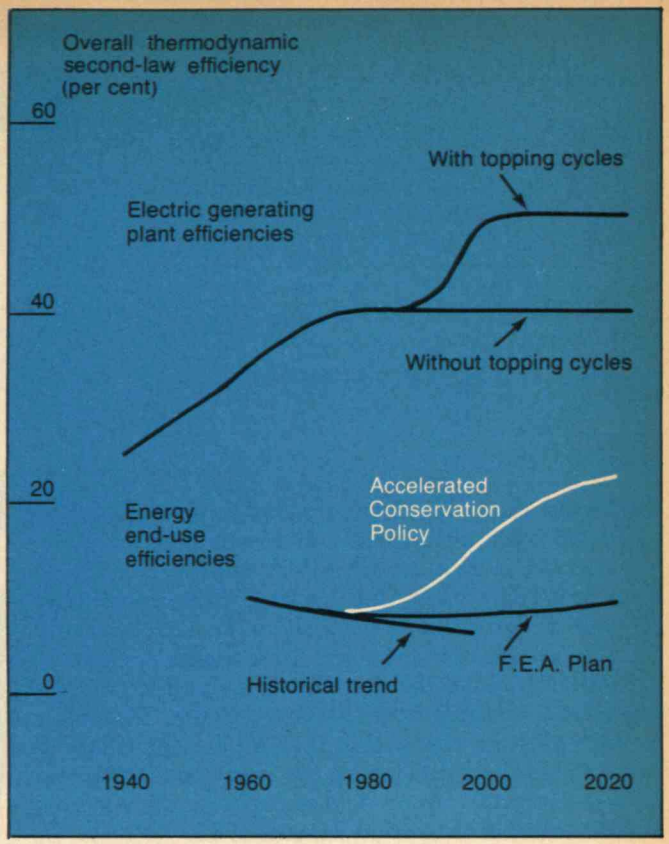
Nothing resembling a free marketplace exists today, given the fact of cartel pricing for petroleum, and considering the long history of massive federal subsidies to the energy supply industry — research and development grants, depletion allowances, guaranteed return on utility investments, etc. This fact has often been obscured by those who promote price deregulation as the only means for a comprehensive energy policy.

Strong Regulation Needed

Our proposed policy for accelerated energy conservation depends heavily upon mandatory measures to improve



An Accelerated Conservation Policy which increased energy efficiency in our society by only about one percentage point every two-and-a-half years could allow an uninterrupted growth of three per cent per year in G.N.P., with little or no increase in energy demand.



An enormous untapped potential for conservation, discovered as we proceed along the conservation road, could well allow continued economic growth with no more energy than we use today. The efficiency improvements proposed by the authors may seem ambitious, but they are still less than those accomplished in the electric power industry.

end-use efficiency. This approach will inevitably raise arguments aginst tampering with the so-called "free market." Direct intervention must be considered, however, because price alone cannot provide sufficiently strong motivation for accelerated conservation.

Price increases are limited as a conservation stimulus even for the industrial sector, because energy cost still averages well below 10 per cent of value added for all manufacturing. Thus, even large additional rises in fuel prices will not necessarily place overwhelming conservation pressures upon manufacturers.

Congress has recognized this aspect of energy policy, and has acted wisely in passing the mandatory automobile fuel economy legislation. By forcing the desired trend in new car efficiency, this measure will mean a continuing reduction in gasoline consumption throughout the next decade and beyond. Moreover, the law can reduce gasoline consumption without the need for decontrolled gasoline prices.

The transition to a conservation plan requires nothing short of a massive restructuring of the priorities for deployment of resources, both capital and technological. This shift must take place in a relatively short period so that we won't exhaust our capital resources in marginal ventures.

Only the Beginning for Conservation

A conservation strategy could actually have more profound far-term implications than near-term. Current technology can clearly provide the 21 Quads of incremental annual savings over the next eight to ten years. But considering that overall second-law fuel efficiency would still be less than 11 per cent at that point, aggressive research into end-use efficiencies could almost certainly advance the technology still further. A concerted effort in this area has not even begun, and the untapped potential for improvement may well exceed anything on the horizon among the various alternative energy supply options. If, for example, we were able to continue improving energy efficiencies by about one percentage point every two and a half years, we could sustain an uninterrupted growth in real G.N.P. of 3 per cent per year for the next three decades, and still consume no more energy than we do today (*see above left*). Even then, our overall end-use efficiency would be only 20 per cent, about equal to that of the steelmaking process today.

The improvements in energy end-use efficiency that we postulate are, in fact, not all that remarkable. As you can see from the graph at the right above, they are still less than that accomplished over a comparable number of decades in improving electric generating plant efficiencies. The latter process, of course, has been subjected to enormous and continuing commitments of technological resources —the same prescription that is suggested here for energy end-use processes.

Some progress has already been made in overcoming the notion that the conservation of energy is synonymous with decreased economic activity. There is a growing

awareness that capital investments in energy-saving devices can often yield greater dividends than comparable investments in new supply. Given appropriate stimulus, then, it is quite likely that the U.S. economy will make substantial progress toward more efficient end-use of energy over the next ten years. Unfortunately, there is little appreciation of the fact that conservation can play a major role in our long-term energy future. This misconception must be changed so that we can focus attention upon the task of developing the new conservation technology needed to insure continuing reductions in energy consumption in the period beyond 1985.

Perhaps the most decisive of all arguments in favor of conservation is the dividend that such a policy can buy in terms of time — the time needed for a thorough, searching, and balanced investigation of all possible energy supply alternatives, including the complete costs of their environmental and safety impacts.

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This article is based on long-standing work being done at Thermo Electron Corp. on energy conservation technology and energy policy issues.

MIT '77

Articles

Departments

Toys to Aid Handicapped Children: A Unique Learning Experience

"We know only one way to get people to innovate: turn them loose in a real situation where they have the opportunity to be creative, and where their contribution is needed," says Robert W. Mann, Uncas A. Whitaker Professor of Biomedical Engineering.

His "freshman seminar" at M.I.T. is organized accordingly. There is only one requirement: that student and faculty agree to work together on a biomedical problem of mutual interest. "We recruit a new group each year and give them the opportunity to observe the communication and learning problems of children who have severe physical impairments," he explains. The setting is the residential day care program for handicapped children at Kennedy Memorial Hospital in Brighton. The M.I.T. students observe the children and work with them to identify therapeutic devices and aids that might be helpful. When the student has built what he or she thinks is a useful "toy" that will aid rehabilitation, it can be tried in the hospital to see if it works. And if it does not, *why* not.

Professor Mann stresses the importance of giving students the opportunity to experience handicapped children, because this exposure often results in a very personal commitment. (Several of his students have gone on to medical school.) "Until an individual has direct experience with a minority, he or she doesn't have the opportunity to create a bond of empathy."

For his students, Professor Mann is primarily interested in engineering education which includes the experience of using knowledge in an engineering situation. Simple acquisition of knowledge is not enough.

"When I play the research role, the instrument for research is the paper. When that is done I move on to other things." But not so for students: "In design engineering, I want to see the design practically used."

To make their creations work, students must learn about electronic

The Magic Light Pen, used to strengthen eye-hand coordination, was developed by Mindy Lipson, '76, who is now in medical school. It is one of two "toys" to be manufactured at Goodwill Industries of Harrisburg, Pennsylvania, under a grant from the Whitaker Foundation to Creative Technological Aids, Inc.

Scott Foster, '76, (center) developed Space Control. A joy stick aims a spot on the TV tube so the non-verbal child can answer questions such as "which is the circle?"

and electromechanical systems. And they delight in sharing this understanding. Transparent plastic covers on the "toys" reveal their parts to the youngsters' delight — they call them "computers." Students' lack of experience poses one persistent problem: some of the designs are impractical and complicated — a long way from the possible transition into commercial manufacture; but that's all part of learning, too.

Some students' ideas:

The "Magic Light Pen" was devised to strengthen eye-hand coordination. Usually a handicapped child attempts to draw straight lines and patterns using felt-tipped pen and paper under direct supervision of a therapist. The use of "Magic Light Pen" eliminates the need for continual attention.

Visualize a box with a metal surface on which any arbitrary pattern can be placed. As long as the child keeps the "Light Pen" on the path, the light in the pen stays on. When he or she falls "off," the light goes off. And when the end of the path is reached successfully, a bell rings, creating positive reinforcement.

"Secret Code" was developed to train short-term memory. A knob on top is first set to "load." The therapist pushes white buttons in some sequence appropriate to the child's training needs (perhaps as simple as pushing the buttons in numerical order or in some arbitrary sequence.) Inside the machine, a primitive computer memory remembers the order in which the therapist "programs" the buttons. Then the knob is turned to "use" and the child is asked to duplicate the sequence. Buttons light if correct; wrong buttons won't respond. When all are correctly pushed, a red light comes on, and the buttons flash in unison, again a positive reinforcement.

"Secret Code" is extremely successful in developing memory of order-

Professor Roger Kaufman, faculty advisor to C.T.A., Inc., and a patient work with Flash Word, designed by Dennis Burke, '75. The therapist draws a cartoon representing a word (car, dog, etc.), and perforates a code corresponding to each letter along the bottom of the cartoon. When the coded cartoon is inserted into the Flash Word box, only the correct letter block will line up with the perforations and give the child the positive reinforcement of a light. When all letter blocks are assembled in correct order to spell the word, the lights under each letter flash in unison.

ing numbers, says Professor Mann. By using overlays over the keys it is also used to train letter recognition and spelling, all fundamental sequential memory training tasks.

"Puff, the Mighty Elephant" is an innocuous form of the traditional shooting gallery. Elephants parade across the African veldt while the youngster attempts to fell them with blasts of air from a syringe. Muscular coordination is called for — both in synchronizing air-gun movement with the moving elephant, and in squeezing off the air blast.

Other devices are designed to train character recognition, motor planning, visual field, tremor compensation, numbers, and colors. One machine has proved valuable as a communicator for a nonverbal child with multiple handicaps.

Rehabilitation requires a long training process, without the drama of the operating room or wonder drugs, says Professor Mann. But for students who design "toys" and the children who benefit from them, the rewards are myriad; and the excitement of discovery is shared by student and patient.

Some 15 toys have already been built. Professor Mann and his colleagues have formed a non-profit corporation called Creative Technological Aids, Inc. Their goal is to produce small lots of the more successful devices in child-proof, attractive versions, together with descriptive information on how best to exploit them. These "toys" will be tested and refined in a range of therapeutic settings. Then, C.T.A. hopes to win patents and interest commercial manufacturers in production. Profits will support new designs. — *M.L.*

Rehabilitation requires a long training process, without the drama of the operating room or wonder drugs. But for students who design "toys" and the children who benefit from them, the rewards are myriad; and the excitement of discovery is shared by student and patient.

"We Want M.I.T. Students to Write Better . . ."

Can M.I.T. students write? Do they want to? Does M.I.T. care if they do or not?

Some students can write, some can't. A few want to very much. And M.I.T. does care.

"We want M.I.T. students to write better so that they will be able to play a more valuable role in society and to express their individuality with greater ease and satisfaction. We want them to write better about their work and about themselves. Our object is to develop a writing program which will achieve these objectives," say Harold J. Hanham, Dean of the School of Humanities and Social Science, and Donald L. M. Blackmer, Associate Dean.

But this is easier said than done.

A steadily expanding experimental writing program is five years old now. Those years have been rewarding — and tortuous.

The most popular writing subject, Writing and Experience, began in the fall of 1972 as an experiment. The emphasis in class is on discussing short student papers. Student participation is dominant; the teacher plays an unobtrusive role. Grades are downplayed on the ground that they hinder shared learning by encouraging invidious competition. And model writing is regarded as a possible impediment to students trying for the first time to find out what they have to say. A congenial supportive environment is created where students come in and read their work to other students. "It is a relaxed, informal, and — from the standpoint of some — wholly uncritical atmosphere," explains Dean Blackmer. "Some classes are taught at night with guitars and a jug of wine. But that's O.K. if students are being worked hard and learning a lot in the process."

"It is a relaxed, informal, and —from the standpoint of some, wholly uncritical atmosphere . . . Some classes are taught at night with guitars and a jug of wine."

Differences in teaching methods gradually brought uneasiness between the Writing and Experience group (the pilot Writing Program) and the Literature Section of the Department of Humanities. The Literature Section's emphasis is on reading as well as writing, to provide students with models for study. The teacher plays an active, more conventional role.

By spring, 1973, it was clear that the central concerns of the Literature Section and those of the Writing Program could not be expected to coincide. In fact, they continue to diverge. "One side saw itself as defending traditional academic values, the other as fighting entrenched academic conservatism. From there it was a short step to accusations from the one side of lack of professionalism, and from the other of elitism and authoritarianism," explains Dean Hanham.

To ease the growing tension, Dean Hanham asked in 1975 for an evaluation of the Writing Program by an independent committee, chaired by Nathan Sivin, Professor of the History of Science and Chinese Culture.

The Sivin Report

The Sivin Report summarized the goals of the Writing Program, discussed the writing needs of M.I.T. students, and evaluated the success of the program in meeting these goals and needs. The Program staff observes, says the Sivin Report, that "most M.I.T. students, precisely because they are used to carrying out technical tasks successfully, tend to be less sure of themselves when confronted with the ambiguous blend of intangibility and concreteness that is inevitable in human relations. This lack of confidence is reflected in writing as in other acts of communication. . . .

"Practice at confronting the responses of a spectrum of readers in an atmosphere of constructive (though sometimes passionate) criticism dispells a great deal of the mystique of writing. . . .

Dean Harold J. Hanham on the Writing Program: "The problem of writing at M.I.T. is now being tackled directly and on a broad front . . . A lot of progress has already been made, although it will still be some years before we have a fully articulated program. We need the help of the whole M.I.T. community in developing that program." (Photo: Mark James, '78)

"Teachers in the Writing Program see the growth of individual self-knowledge, the ability to react to others constructively, motivation toward craftsmanship, and the ability to read literature with understanding as complementary goals to which students as well as teachers must bend their efforts."

Some of the report's recommendations:

Develop new subjects to create a balanced program, including the teaching of expository writing. Establish a resource center incorporating diagnostic services, aids to individual study, tutorials, and a variety of long and short workshops and seminars. Devise a monitoring system to identify undergraduates in need of writing skill. Evaluate senior staff members individually. Lower the present proportion of part-time instructors. Remove the Writing Program from the Humanities Department and attach it to the Office of the Dean of the School of Humanities and Social Science. Appoint a tenured faculty member to head the Program.

"Every effort should be expended to make M.I.T. as attractive as possible to students who believe they have the potential to become accomplished writers and who wish to make creative writing more than an incidental part of their undergraduate experience."

The Committee's recommendations have for the most part been accepted with one major exception: the Writing Program will *not* be removed from the Department of Humanities. The reason: "Our objective . . . is to build a broadly-based program in which many kinds of writing are taught and different styles of teaching are encouraged. To separate these groups administratively seemed to us counterproductive and certain to encourage precisely the sort of intolerance and competitiveness we have been seeking to overcome," explains Dean Hanham.

Future Writing Offerings

Future writing offerings will include alternatives in four categories: science writing (communicating information about science to nonscience audiences — a field absent from the M.I.T. curriculum for several years); technical writing (communicating technical information to other specialists — long a part of the M.I.T. curriculum); creative writing (poetry, fiction, drama) designed primarily for students interested in becoming professional writers; and writing for general education (improving the capacity for expression and communication of the individual student regardless of the student's contemplated profession). "The emphasis here is not so much on producing well-crafted literary works as on developing the ability to express feelings and ideas and to communicate effectively with readers and listeners," says Dean Hanham.

Next year there will be more subject offerings in writing than ever before. And for the first time there will be a writing program organized on a permanent basis and staffed primarily by faculty members rather than by instructors and lecturers. The new science writing program — one of the four fields planned for next year — is being partially supported by a grant from the DeWitt Wallace Fund, says Dean Blackmer. — *M.L.*

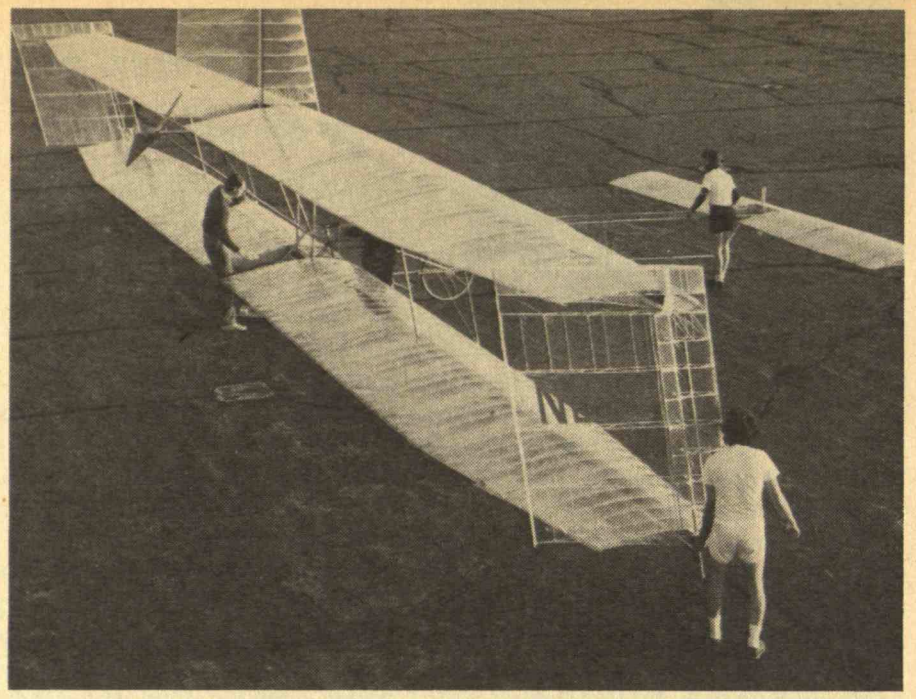
The Writing Program: "I Couldn't Live Without It"

Who is attracted to the Writing Program? "There are those who simply desire to learn to write, and those who, in addition, are attracted by a counter-cultural oasis that creates a home at M.I.T. — something the rest of the M.I.T. environment often fails to provide," says Donald L. M. Blackmer, Associate Dean of the School of Humanities.

"I drifted into [the Writing Program] as a freshman and found I couldn't live without it," says Nicole Schultheis, '77. "It was an enclave that I could go to when people didn't talk to me and treated me as if I didn't exist. I could go there, sit down, talk to people, and have my coffee." She feels the writing program allowed her to express herself, to feel more at ease with herself. She appreciated the absence of constant pressure of exams and homework. The informality, she says, helped to promote more honest critiques of one another's work.

Harry Gammerdinger, '78, feels he would benefit from a more critical atmosphere in the writing experience course. The discussion in class could be in more depth, he says.

What is it like to attend a class in the Writing Program? Classes vary. Hugh M. Blumenfeld, '79, describes his favorite: "We leave our writing in the Writing Program office where students can read it and give a critique into a tape recorder. The result is honest comments and not a chorus of 'yeah, I agree with that.' In class we may sit in a semicircle, conjuring up verbal images. One inspires another. The class is recorded, so verbal expression can be transcribed. We taped a spontaneous 25-minute story I told in class, which made a ten-page story when transcribed."



The man-powered plane built by M.I.T. students goes forward "tail" first. Their goal: to build a minimum weight airplane with the ability to turn. Interest in the project was stimulated by the Kremer Prize, an $86,000 purse to go to the first entrant whose man-powered aircraft can fly a roughly two-mile figure-eight course around two markers a half-mile apart.

Man-Powered Flight: "A Great Educational Device"

"It is the greatest educational device for young engineers I have ever seen," says Aeronautics Professor Eugene E. Covert. He speaks of man-powered flight, a project at M.I.T. since 1969, when six students began an independent study under his direction.

Their interest was stimulated by a desire to win the Kremer Prize, established in the mid-1950s by the English industrialist and physical fitness enthusiast, Henry Kremer. His prize has now reached the value of 50,000 pounds ($86,000), for the first entrant whose man-powered aircraft can accomplish this task: take off under your own power; climb to ten feet, fly a figure-eight path around two poles one-half mile apart, clear ten feet in altitude, and land. After landing, the machine has to be in good enough condition to be taken off again by someone else.

Twenty craft have left the ground since, but only one (the Japanese machine) has yet even attempted to fly Mr. Kramer's tough course. And, of course, no one has come close to claiming the prize.

"There are two philosophies," explains Professor Covert: "either design a bicycle that flies, or design an airplane that happens to be powered by a person. The former approach is unlikely to work — a bicycle operates on the ground. We view our study as an airplane that just happens to be powered by people."

M.I.T. students concentrated on two issues: building a minimum-weight airplane ("even if a part was too light weight to stand up in testing, we would remove the broken part, repair it, re-install it and forge ahead"), and turning ("everyone had flown straight and level, so we studied turning right from the start"). Access to modern materials not commonly used in airplanes has facilitated the task.

But it is a difficult project. Indeed, "the design is complicated enough that we can make a decision in the fall, unsure of its consequences, and in the spring realize we have built ourselves into a box. But it is the experience that helps students to make a right decision the next time."

Students do the designing, under the supervision of Professor Covert and Aeronautics Professor James W. Mar, '41. "We encourage them to make decisions," says Professor Covert, "and if we don't agree, and can't persuade them, we will let them make the decision. If it's a bad choice then they

Technical Difficulties

Why it is difficult to win the Kremer Prize according to Professor Covert:

The description of the flight path is sufficient to specify the design of the airplane. Technical difficulties arise because:

— The relatively small power a person can generate. That is, the power to weight ratio is very small, usually less than .01 horsepower per pound. And the power output is strongly dependent upon the time interval over which the power is required.

— The limited power requires, in turn, the product of the drag, or the wind resistance, and velocity be minimized. The drag depends linearly upon the surface area of the configuration and quadratically upon the lift that is developed. The latter is reduced as the weight is decreased.

— Turning requires an increased lift, and greater concentration by the pilot. Increased lift implies more drag, and hence the pilot must also pedal more strenuously. This requires additional concentration of effort. So the demands on the pilot become extreme during a turn; he must pay closer attention to flying and at the same time closer attention to pedaling.

These requirements force the design to be one with extremely low drag, extremely low weight, and "good handling qualities". The compromises between these three competing requirements are difficult to make.

The *BURD II* is nearly as complicated as any other light airplane. Thus the construction process is about as time consuming as any other "home built airplane," but the margins for error are much smaller.

pay the price — and they learn."

M.I.T.'s first man-powered airplane broke up in a test flight in April 1974. Now a new student group is in the process of satisfying themselves that the second machine is ready to fly. It is substantially completed but needs ten to 12 hours of taxi tests. "Our third or fourth effort might win the prize," says Professor Covert. "It is a trial-and-error experiment, which always involves a number of trials."

Even for testing, the wind must be less than one knot because the aircraft is so light, and so fragile. So a weather watch notifies the group — often in very early morning, since calmest weather is often at dawn.

Qualifications of the pilot are not easy to fill, either; he or she must be a licensed pilot, weigh less than 140 pounds, and be able to generate in the neighborhood of 6/10 of a horsepower for four minutes — a task that might be within the range of a top-seeded bicycle racer. (Takashi Kato, a 21-year-old engineering student who is a leading contender for the Kramer prize at Tokyo's Nihon University, trains by daily pedaling a roller-mounted bicycle for an equivalent of 31 miles.)

The pilot must be carefully trained. At a flight speed of 30 feet per second, the aircraft and crew possess 10,000 foot pounds of energy — a lot of energy to manage. The pilot must be comfortable handling the plane on the ground, explains Professor Covert. Then he must concentrate on learning to maneuver just before he comes on the ground and just after. When everyone is comfortable with this, the next step is to get in the air. — *M.L.*

"There are two philosophies: either design a bicycle that flies, or design an airplane that happens to be powered by a person. The former approach is unlikely to work — a bicycle operates on the ground. We view our study as an airplane that just happens to be powered by people."

Two New Major Gifts ($10 Million) Spur Planning for a $25.5 Million Health Center

Two major gifts, totaling $10 million, came to M.I.T. late this spring for work in the health sciences and health care management. They brought to $19 million the total available for a $25.5 million health center complex which is now being planned for construction on the East Campus — at Carlton and Amherst Streets; and to $126.5 million the total of giving to the Institute's $225 million Leadership Campaign.

The two gifts comprise $7 million pledged by the Whitaker Foundation and $3 million from the Education and Medical Fund of the New York Community Trust. The Whitaker Foundation is associated with the late Uncas A. Whitaker, '23, and the Education and Medical Fund is a donor advisory fund created by Mr. and Mrs. Whitaker.

Mr. Whitaker was Chairman of the Board of AMP, Inc., at the time of his death in 1975; he was a Life Member Emeritus of the M.I.T. Corporation. Mrs. Helen F. Whitaker is now a member of the Corporation, and she has long shared her husband's interests in the life sciences at M.I.T. Their earlier contributions helped make possible the Harvard-M.I.T. Health Sciences and Technology Program and construction of the Whitaker Building, which houses work in biology, nutrition, and food science.

The new health center project was announced early this year when $9 million was given toward its realization by the Pew Memorial Trust of Philadelphia. With the Whitaker gifts, that project is now more than 70 per cent financed — barely two months after it was first announced. The Pew and Whitaker gifts are among the largest ever received by M.I.T.

The Whitaker gifts came on the second anniversary of M.I.T.'s five-year Leadership Campaign, and they prompted President Jerome B. Wiesner to optimism. There is, he says, "growing realization that the kind of understanding that M.I.T. brings to the relationship of science and technology to our society is rare — and urgently needed." He is convinced, he said, that "maintaining the cutting edge of this institution is the most important thing we can do today." — *J.M.*

Students

A "Godspell" to Rival the Professionals'

"Almost every trick of the theatrical trade" found its place on the Kresge Auditorium stage when the M.I.T. Musical Theater Guild staged "Godspell" this spring. The show, said The Tech's reviewer Kathy E. Hardis, '78, created "a spontaneous and festive love-thy-neighbor mood," and the cast took full advantage of "endless possibilities for improvisational theatrics. . . . Deserving of the highest possible praise," she said. Among Ms. Hardis' plaudits for members of the cast: Michael I. Weitz, '78, "romps and clowns on stage in a wonderful manner . . ." Lanier Leonard, '80, "sings, dances, and moves around with joyous abandon. The audience even clapped and stamped their feet to his lively rendition of 'We Beseech Thee.'" Constance Herron, '80, sang the popular "Day by Day" with "power and stage presence." And Michael R. Connor, '79, designed "an interesting amalgam of wooden crates and nets representative of a dock . . . works extremely well." (Photos: Gordon Haff, '79)

"It's probably the only day of the year that there are all smiling faces in the crowd and everyone's happy." That's the recollection of Patriot's Day and the Boston Marathon by Frank Kenney, '78, who ran the 26-mile course in three hours and 50 seconds. (Photo: Alex C. Edsall, '80, from The Tech*)*

M.I.T. In the Boston Marathon: Doing What Man Was Not Designed to Do

Four M.I.T. students ran in the 1977 Boston Marathon on Patriots' Day, April 18. It's an arduous race — over 26 miles from Hopkinton, Mass., to the Prudential Building in Boston, with the highest elevation ("heartbreak hill") nearly 20 miles into the race, in Newton.

"What is it that sends many of the country's best marathoners to Boston every April?" thought Glenn Brownstein, '77, of The Tech. *"And what is marathon running all about?" For answers, he sought out three of the four M.I.T. entrants — the fourth, Steve E. Kissel, '78, couldn't be reached by* The Tech's *deadline. Here are excerpts from his report, reprinted by permission from* The Tech *of April 24:*

Frank Kenney, '78, has been running track for the last five years, two years in high school and three at M.I.T. When he heard about the Marathon in the papers, he decided to try it once and set out to qualify for the 1977 running.

His first attempt came in the ill-fated Silver Lake Marathon, marred by snow, sleet, and biting cold. Kenney completed the course in just over the three-hour time limit needed to qualify for the B.A.A., and so he entered a Veterans of Foreign Wars Marathon in Lowell on March 13, just five weeks before Boston. His time of 2:46 not only qualified him for the Patriots' Day race but also placed him 19th, a fringe benefit.

While many marathoners have taken to special dietary regimens in an attempt to give their bodies an edge over the grueling 26-plus miles, Kenney did what came naturally: "I used mostly track [team] workouts to prepare. I did some extra distance running when I was in Florida over spring vacation, but no dietary-type junk."

"All the Girls Went Nuts When They Saw My M.I.T."

Kenney told what happened the day of the race: "I got up about 10 o'clock, and just sat around and rested until the race began. One problem: I didn't do enough stretches before the race and got cramps almost immediately after the start.

"It went pretty well until the 18-mile mark, at which point I'd done 1:50 (six-minute miles). Then I died and finished in about 3:03 [*sic* — Kenney's official time was three hours, 50 seconds]. The heat was definitely a factor."

More than one million spectators lined the route Monday afternoon, but that didn't bother Kenney at all: "People were good —there were lots of them handing out drinks on the way, although it wasn't too easy to tell what it was sometimes."

One thing does stand out in his mind, however: "The race was great, especially in Wellesley — all the girls went nuts when they saw my M.I.T track T-shirt."

"Like Running in the Olympics Without Being a Champion"

For Fred Silver, a graduate student in textile technology, it was his third effort on the Boston course, and a successful one. Not because he ran a very respectable 2:52:28 for 551st place, but because he *ran.*

Much has been written about the "loneliness of the long distance runner," but perhaps "loneliness" is not the proper word to describe it. Running is a kind of "soul food," especially the marathon, in which the personal goal is uppermost in every runner's mind: not necessarily to win, although the world-class runners do consider that, but to do your best, whatever that may be. And the atmosphere in Boston is extremely conducive to the individual pursuit.

According to Silver, "In Boston it's like running in the Olympics without being the Olympic champion — the crowd cheers for everyone. It's a different type of feeling; to know that no matter how fast you ran, you finished.

"It's the atmosphere here, all the runners — this year, I walked the first three minutes of the race because of so many people running — meeting people, the crowd support. It's probably the only day of the year that there are all smiling faces in the crowd and everyone's happy."

The course itself: "It's different from most. It starts downhill and ends downhill; it's difficult to run downhill when you're tired. And the weather's so unpredictable: two years ago it was 55 degrees, last year about 95, and around 80 Monday."

Silver was a javelin thrower in college, although he ran track in high school. "I'm really interested in running, like it, and the Marathon is a good reason to train. I saw some guys on TV running it, and that's how I got the idea originally."

Boston was Silver's third marathon in the last year, and his training method was roughly the same for all of them. "I run 90 miles each week for the eight weeks prior to the race. I do mostly physical training; I don't really change my diet before a marathon."

"I'll Do It Again Next Year, and I'll Make It!"

And although Silver's stay at M.I.T. will end this term, he intends to be back next year, as does Tom Richard, a graduate student in chemistry. Richard fell victim to a typical danger of training in Boston: he stepped in a Harvard Bridge pothole while running and pulled a muscle, cutting off his training and all hopes of running in the 1977 Boston Marathon.

Richard admits candidly, "It was really stupid, running in the dark on the bridge. I run at night because it's the only time I have free; being a grad student makes it impossible to get any time during the day. So I was running on the Boston side of the Harvard Bridge about three weeks ago and hit a pothole, pulling a muscle in my right foot."

Peter Berke, '78, and Nancy Hartle, '80, scored an easy victory in the 1977 elections, and they're now President and Vice President, respectively, of the Undergraduate Association. Mr. Berke's platform emphasized "love and peace"; after the election he told The Tech *that "M.I.T. can be a fun, friendly environment to be in. . . . Hard work, pleasure, and self-realization are symbiotic, not parastic. People shouldn't give up!" (Photo: Mark James, '78)*

Unlike Silver and Kenney, Richard is a newcomer to running, having only "gotten into running about a year and a half ago. I didn't run before that. Once I got into running, I thought that I might as well try to do the Boston Marathon."

Richard succeeded in qualifying for the Boston Marathon in his first marathon, the Ocean State Bicentennial Marathon in Newport, R.I., last September. "I ran ten and a half miles each day for two or three months before the race. I qualified, but I decided that I'd run 16-mile circuits for Boston because I felt I needed it after my Rhode Island experience — it really hurt at the end of the race.

"It was a bad winter for training. I was able to get out only when the snow finally melted around late February. Once I started running. I decided that the week before the marathon I'd go down to ten miles each for three days, then do just three or so miles a day for the last four days before the race. But then I got injured . . . it's really a blow."

Like most marathoners, however, Richard's year-long quest to run Boston was not a "one-shot deal": he's determined to reach the starting line in 1978. "I'll do it again next year, and I'll make it; I won't make a mistake training."

For Fred Silver, Frank Kenney, and Tom Richard, the BAA Marathon is something special, something unique. Marathoning is one of the only sports in the world where a first-time competitor can compete side-by-side with world-class athletes. Importantly, it's a sport where winning is not crucial, except the victory of the spirit over the body —man was not designed to continuously run 26 miles.

A Victory for "Love and Peace" at M.I.T.

For most of the past decade, candidates for student government at M.I.T. have campaigned on issues over which they really could expect to have no control: the Institute's budget priorities, rising tuition, board and room cost, grade inflation . . .

This year it was a little different. There were the usual appeals and promises for more student participation in government, more interest in academic student-faculty committees . . .

And then there was Peter I. Berke, '78, and Nancy Hartle, '80, a ticket — for President and Vice President, respectfully —dedicated to "love and peace." "It isn't just tuition, it isn't just grades, its pressure. M.I.T. is an isolating place, and there is absolutely no reason for it."

Their platform: a friends-with-the-faculty movement, a club as comfortable as the Faculty Club for the students, "lawn furniture on the lawns, places to relax and hang out . . . . This place looks bleak and it's getting bleaker," Mr. Berke told *Thursday*. "Future works of art acquired by M.I.T. should be colorful and comfortable. It should be possible to sit, climb, or study on them. Fill the Great Court with trees and hang hammocks on them!"

"Do you really want to leave M.I.T. the way you found it?" asked the Berke-Hartle ticket.

When the 1,175 votes — 28 per cent of the eligible voters — were counted, it was Berke-Hartle in an easy victory.

Mitchell Rothstein's Hard Decision: Will It Be Shakespeare or Mathematics?

This month brings a big change in the life of Mitchell J. Rothstein, '77: from mathematics student to Shakespearian actor.

For at least a year starting this month, when he joins the Utah Shakespearian Festival, Mr. Rothstein wants to find out "what it's like to be a professional actor." Then, he thinks, he'll be satisfied to go back to school, somewhere, for a Ph.D. in pure mathematics; but perhaps he'll opt for an acting career, after all.

In Cedar City, Utah, this summer Mr. Rothstein will perform in *Coriolanus, Romeo and Juliet,* and *The Taming of the Shrew,* given in repertory. It's "one of the best seasonal Shakespeare festivals in the country," says Professor Murray Biggs; he's been Mr. Rothstein's mentor as Director of the M.I.T. Shakespeare Ensemble.

Though Mr. Rothstein had "a passion for acting all through my childhood," his interest really flowered when he joined the Shakespeare Ensemble in 1974. He's been in all its major productions — including the part of Iago ("a really fantastic role") in *Othello* this spring.

After four years and a bachelor's degree in mathematics, Mitchell J. Rothstein, '77, is headed for Cedar City, Utah, and the Utah Shakespearian Festival. He wants to get acting out of his system — but there's always the possibility that the stage will oust the calculator in his future. (Photo: Ephraim M. Vishniac, '78, from Technique*)*

SPECIAL REDUCED ALUMNI RATES

THIRTEENTH ANNUAL TOUR PROGRAM — 1977

1977 marks the thirteenth year of operation for this unique program of tours, which visits some of the world's most fascinating areas and which is offered only to alumni of Harvard, Yale, Princeton, M.I.T., Cornell, Univ. of Pennsylvania, Columbia, Dartmouth, and certain other distinguished universities and to members of their families. The tours are designed to take advantage of special reduced fares offered by leading scheduled airlines, fares which are usually available only to groups or in conjunction with a qualified tour and which offer savings of as much as $500 over normal air fares. In addition, special rates have been obtained from hotels and sightseeing companies.

The tour program is consciously designed for persons who normally prefer to travel independently and covers areas where such persons will find it advantageous to travel with a group. The itineraries have been carefully constructed to combine as much as possible the freedom of individual travel with the convenience and savings of group travel. There is an avoidance of regimentation and an emphasis on leisure time, while a comprehensive program of sightseeing ensures a visit to all major points of interest. Each tour uses the best hotel available in every city, and hotel reservations are made as much as two years in advance in order to ensure the finest in accommodations. The hotels are listed by name in each tour brochure, together with a detailed day-by-day description of the tour itinerary.

The unusual nature and background of the participants, the nature of the tour planning, and the quality of the arrangements make this a unique tour program which stands apart from the standard commercial tour offered to the general public. Inquiries for further details are invited.

AEGEAN ADVENTURE

23 DAYS $2250

This original itinerary explores in depth the magnificent scenic, cultural and historic attractions of Greece, the Aegean and Asia Minor, including not only the major cities but also the less accessible sites of ancient cities, together with the beautiful islands of the Aegean Sea. Visiting Istanbul, Troy, Pergamum, Sardis, Ephesus and Izmir (Smyrna) in Turkey, Athens, Corinth, Mycenae, Epidauros, Nauplion, Olympia and Delphi on the mainland of Greece, and the islands of Crete, Rhodes, Mykonos, Patmos and Santorini in the Aegean. Total cost is $2050 from New York. Departures in April, May, July, August, September and October 1977. (Additional air fare for departures in July and August.)

SOUTH AMERICA

28 DAYS $2675

From the towering peaks of the Andes to the south Atlantic beaches of Rio de Janeiro, this tour travels more than ten thousand miles to explore the immense and fascinating continent of South America. Visiting Bogota, Quito, Lima, Cuzco, Machu Picchu, La Paz, Lake Titicaca, Buenos Aires, the Argentine Lake District at Bariloche, the Iguassu Falls, Sao Paulo, Brasilia, and Rio de Janeiro. Total

cost is $2675 from Miami, $2691 from New York, with special rates from other cities. Departures in January, February, March, April, May, July, September, October and November, 1977.

THE ORIENT

29 DAYS $2645

A magnificent tour which unfolds the splendor and fascination of the Far East at a comfortable and realistic pace. Visiting Tokyo, the Fuji-Hakone National Park, Kyoto, Nara, Nikko and Kamakura in Japan, as well as the glittering temples and palaces of Bangkok, the metropolis of Singapore, the fabled island of Bali, and the unforgettable beauty of Hong Kong. Optional visits to the ancient temples of Jogjakarta in Java and the art treasures in the Palace Museum of Taipei. Total cost is $2645 from California with special rates from other points. Departures in March, April, May, June, July, September, October and November, 1977 (extra air fare for departures July through October).

MOGHUL ADVENTURE

29 DAYS $2575

An unusual opportunity to view the magnificent attractions of India and the splendors of ancient Persia, together with the once-forbidden Kingdom of Nepal. Visiting Delhi, Kashmir (Bombay during January through March), Banaras, Khajuraho, Agra, Jaipur and Udaipur in India, the fascinating city of Kathmandu in Nepal, and Teheran, Isfahan and the palaces of Darius and Xerxes at Persepolis in Iran. Total cost is $2575 from New York. Departures in January, February, March, August, September, October and November, 1977.

THE SOUTH PACIFIC

29 DAYS $3140

An exceptional tour of Australia and New Zealand, from Maori villages, boiling geysers, ski plane flights and jet boat rides to sheep ranches, penguins, the real Australian "Outback," and the Great Barrier Reef. Visiting Auckland, the "Glowworm Grotto" at Waitomo, Rotorua, Mt. Cook, Queenstown, Te Anau, Milford Sound and Christchurch in New Zealand and Canberra, Melbourne, Alice Springs, Cairns and Sydney in Australia, with optional visits to Fiji and Tahiti. Total cost is $3145 from California. Departures in January, February, March, April, June, July, September, October and November 1977.

EAST AFRICA

23 DAYS $2310

The excitement of Africa's wildlife and the magnificence of the African landscape in an unforgettable luxury safari. Visiting Lake Naivasha, Lake Nakuru, Samburu Reserve, Treetops (Aberdare National Park), Masai-Mara Reserve, the Serengeti Plains, Ngorongoro Crater, Nairobi and Mombasa. Total cost is $2310 from New York. Optional visits are available to the Amboseli and Tsavo National Parks, the Victoria Falls, on the mighty Zambezi River between Zambia and Rhodesia, to Zanzibar, and to the historic attractions of Ethiopia. Departures in January, February, March, May, June, July, August, September, October, November and December 1977.

MEDITERRANEAN ODYSSEY

22 DAYS $1925

A unique and highly unusual tour offering a wealth of treasures in the region of the Mediterranean: Tunisia, with the ruins of Carthage and many other Roman cities as well as lovely beaches, historic Arab towns and desert oases; the beautiful Dalmatian Coast of Yugoslavia, with its fascinating and medieval cities; and the 17th and 18th century splendor of Malta. Visiting Tunis, Carthage, Dougga, Sousse, Monastir, El Djem, Gabes, Djerba, Tozeur, Sbeitla, Kairouan and Thuburbo Majus in Tunisia; Split, Trogir, Sarajevo and Dubrovnik on the Dalmatian Coast of Yugoslavia, and Valletta and Mdina in Malta. Total cost is $1925 from New York. Departures in March, April, May, June, July, September and October, 1977 (additional air fare for departures in June and July).

* * *

Rates include Jet Air, Deluxe Hotels, Most Meals, Sightseeing, Transfers, Tips and Taxes.

Individual brochures on each tour are available, setting forth the detailed itinerary, departure dates, hotels used, and other relevant information. Departure dates for 1978 are also available.

For Full Details Contact:

ALUMNI FLIGHTS ABROAD

White Plains Plaza
One North Broadway
White Plains, N.Y. 10601

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Should a Class Secretary write news about himself? Yes, if he is 100 years old and the last member of his class. On my 100th birthday, April 12, I received presents and long distance telephone calls from friends and relatives, 185 cards, seven bouquets, and three birthday cakes.

A Rotarian for 53 years, I was made a Paul Harris Fellow by my home club. My wife, Minnette, age 91, and I are well and enjoy life in the retirement home below. — **Norman E. Seavey**, Secretary, Apt. 1115, Westminster Towers, 70 West Lucerne Dr., Orlando, Fla. 32801

03

Important and varied items in this month's news of the Class of 1903, involving our distinguished classmates **Andrey A. Potter**, **J. Howard Pew** and **Ben Solomon**.

Andrey A. Potter, Professor Emeritus and Dean of Engineering at Purdue University, Lafayette, Ind., for almost 35 years, was honored by the dedication of the A.A. Potter Engineering Center on the University campus on April 22, 1977. Andrey is honored as teacher, counselor, inventor, administrator, and author by a bronze plaque in one of the buildings of the Center. We proudly applaud the dedication.

J. Howard Pew's gift of $7.25 million in 1974 for a Fuels Research Laboratory in the Ralph Landau Building has now been increased by $9 million from the Pew Memorial Trust, to create a center for health sciences and health services at M.I.T. Our classmates have long admired the formation and success of the renowned Sun Oil Co., solely built by Howard and his energetic brother, Joseph W. Pew of Philadelphia, Penn.

A much-treasured letter regarding our loyal classmate Ben Solomon has been received by your secretary from Dr. Alfred Hurwitz of Augusta, Maine. Ben's affectionate father-in-law for over 38 years has graciously sent a check for $25 to our Class Fund. — **John J. A. Nolan**, Secretary and Treasurer, 13 Linden Ave., Somerville, Mass. 02146

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It is with regret that we report the death on April 30, 1977, of another classmate; **Karl R. Kennerson** of Auburndale, Mass. He was the retired Chief Engineer of the Metropolitan District Water Commission and was in charge of construction of the Quabbin Reservoir in Ware. He also served as Chief Engineer for the New York Water Supply from 1952 to 1956.

Kennerson was a member of the American Society of Civil Engineers, and of the Municipal Engineers of New York City. He was past President of the American Water Works Assn., the New England Water Works Assn. and the Boston Society of Civil Engineers. He leaves two sons and two daughters.

I also must report the deaths of two other classmates: **Frank W. Sharman** of Tucson, Ariz., on October 11, 1974; and **Ralph J. Batchelder** of Pasadena, Calif., on February 5, 1977. I have no other details. — **Joseph W. Wattles III**, Secretary, 600 Washington St., Wellesley, Mass. 02181

09

A short time after graduating in 1909 **Florence Luscomb**, Course IV, gave up the practice of architecture to work for women's suffrage which culminated in the passage of the 19th Amendment. She then decided to devote her energies to fighting for such causes as better conditions for working people, civil rights, particularly for minorities, and equal pay for women. Over the years she has received several honors and citations, many of which have appeared in these class notes. Now we report that services commemorating her past work and her 90th birthday (she was born February 6, 1887) were held by the Community Church of Boston at Boston University's Morse Auditorium and in Memorial Hall Library at Andover, Mass. The class congratulates Florence on reaching her 90th birthday after devoting so many years to humane causes.

Through the Alumni Office we have received the following note from Theora and **Philip Chase**: "It was a beautiful seven months at our place in Kennebunk Beach, Maine. We were busy building a new garage and completing living facilities that convert the pump house into a 'cabin.' On December 12, our expert driver brought us the 470 miles to Wynnewood, Penn., in ten hours; things were hectic at times, but it was interesting. We kept active, and we should continue to be."

In the February class notes **Harold Paine** told of his long-ago hockey team (he was captain of the M.I.T. varsity team) and his attempts to have his great-grandson follow in his footsteps at M.I.T. Recently we received another letter from him at Miami reporting that he had been ill but had recovered and was still working for his great-grandson entering M.I.T.

It is with great sadness that we report the recent death of **Art Shaw**'s wife, Helen Elizabeth, on April 1. She attended our meetings on Alumni Day so regularly that we considered her as a member of the class, and she will be remembered as a gay and friendly attendant at most of our reunions. Betty and Art had been married almost 65 years, their romance starting during high school days in Clinton, Mass. The Class extends its greatest sympathy to Art and his two sons. In memory of Betty the Class has contributed a Memorial Fund to the Sarasota Library nearby Longboat Key where Art and Betty have spent so many winters.

We also have received notice of the death of **Laurence C. Shaw** on December 6, 1976, at Cotuit, Mass. Laurence was born July 1, 1886, in Brockton, Mass., and graduated from Brockton High. For many years he lived in Brockton, where he was employed by a shoe company. He retired in 1955 and took up residence in Cotuit, Mass. For years, as long as his health permitted, he was a regular attendant at our Alumni Day meetings and at our Class Reunions. — **Chester L. Dawes**, Secretary, 74 Wedgemere Ave., Winchester, Mass. 01890

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I sincerely regret having to report the death of Professor **George B. Brigham** who died at Scottsdale, Ariz., on March 2, 1977, after a brief illness.

From 1918 to 1930 Professor Brigham served on the faculties of Tufts, M.I.T., and California Institute of Technology, He was a practicing architect in Pasadena in addition to his Cal Tech teaching duties.

Professor Brigham joined the faculty of the University of Michigan in 1930 as assistant architecture professor. He was promoted to associate professor in 1942 and to full professor in 1949. He served as acting architecture chairman at the U. of M. in 1956-57, and at the time of his death was Professor Emeritus of Architecture at the U. of M. In 1970, he was given the highest recognition in the architectural field by being named to the College of Fellows of the American Institute of Architects.

George was an active architect in Ann Arbor, the designer of the First Unitarian Church and many residences including those of Walter Badger, Otto LaPorte and William Kennedy. His designs were described as "direct and contemporary, blending into the surrounding environments quietly and with dignity."

During World War II, he was associated with the War Production Board as research director for two building prefabrication projects and developed two patented systems for the construction of prefabricated housing. More recently he developed the "Paradome," a folding tent-like structure used for tents and temporary housing.

A George B. Brigham Room in the University of Michigan Architectural School Library was set up in the spring of 1976. Here all his drawings, publications, photos of houses and buildings and memorabilia are to be preserved.

Survivors include his wife, Ilma, who resides at the Scottsdale Christian Home, 3339 N. Civic Center Plaza, Scottsdale, Ariz. 85251; Mrs. Edward C. (Alice) Varnum of Washington, D.C.; and Mrs. Virginia Weller. Professor and Mrs. Brigham had celebrated their 60th wedding anniversary in 1974. — **Larry Cummings**, Secretary, R.R. 4, Connersville, Ind. 47331

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Elmer E. Dawson, Jr. died at his home in Pittsfield, Mass., on February 13, 1977, at the age of 85. Skip, as he was always called by his friends, was born in Great Bend, Kans., went to school in Winthrop, was with us in all our undergraduate years, and received his bachelor's degree in Course II. He was an army major in World War I.

After some years with companies in Boston and Providence, he settled in Pittsfield in 1924, and was first with the Byron Weston Co. in nearby Dalton. He became assistant treasurer of E. D. Jones and Co. in 1938, and its treasurer and a director not long after, and held those offices until he retired in 1957. At our 50th Reunion, Skip was elected to our nominating committee and to the executive committee, and later served for three years as our estate secretary. He was always a generous giver to the Alumni Fund. In 1924 he married Maude Preston Gardner; she died several years ago. Skip is survived by a son, John E. Dawson, of Boston; a sister, Mrs. Wilbur W. Freeman, of Winthrop; and four grandchildren.

After my brief note on the death of **Alfred P. Kitchen** was written for the May issue of the *Review*, one of his sons, Mr. J. William Kitchen, kindly sent me a letter which reads, in part: "My father was 85 years old and had been in a nursing home, partially paralyzed from a stroke, for seven and a half years. This was very difficult for a man who had led a most active life, but he rarely complained. My father was born in Warren, Penn., and graduated from Penn State in 1912 with a degree in Electrical Engineering. He went from there to M.I.T. for a couple of years doing graduate work in this field and working in a lab. My father married Bertha Hoskins in 1917 (she died in 1965) and two sons were born, my brother, A. Paul Kitchen, and myself. The family moved to Philadelphia in 1923 and my father resided in that area until his death. For most of his working life he was connected with the Philadelphia Electric Co. Apart from his work and family Dad had three major interests — music (he loved grand opera and symphony orchestra music, was an excellent flutist, and had a good tenor singing voice), travel (he and mother traveled to 33 different countries), and photography. He was also a lifelong active member of the Presbyterian church.

A thoughtful letter from Mr. William S. LaLonde, '23, told of the death of **Kirk McFarlin** on April 2, 1977, at the age of 84, in a hospital near his home in Short Hills, N. J. He was born in Topeka, Kans., graduated from Williams College, was with us in our third and fourth years, and received his S.B. degree in Course I. In World War I he was an ensign in the U. S. Naval Air Force and served as a meteorologist in Europe. In 1919 he was an engineer with The Barrett Co. in New York City, and in the year after that was a vice president of Hensey and Co., also in New York. Later he was treasurer of Wood Newspaper Machinery Corp., of Plainfield, N. J., and in 1955 was with Rife Hydraulic Engine Manufacturing Co., of New York and New Jersey. He was president of that company at his death. Kirk is survived by his wife, the former Adelaide Hollenbeck, whom he married in 1926; two sons, Kirk McFarlin and Everett McFarlin; and three granddaughters. — **Charles H. Chatfield**, Secretary, 177 Steele Rd., West Hartford, Conn. 06119

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Unfortunately Class Secretary **Azel Mack** is in the Massachusetts General Hospital for what he said would be a "long stretch." He had hoped to see many of his classmates at the Reunion. We wish him a speedy recovery. — *S.F.*

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The early returns for our 61st Reunion at Chatham Bars Inn on June 7 to 9, 1977 indicate that the following were (in April) hoping to attend: Beatrice and **Walt Binger**; **George Crowell** and his son, Bruce, and daughter-in-law, Betty; Hope and **Theron Curtis** and "our two sons with their wives"; Frances and **Paul Duff**; Lois and **Charlie Lawrance** and guests; Gladys and **Francis Stern**; Bettina and **Doug Robertson**; Frances and **Henry Shepard**; Frieda and **Hy Ullian**; Marjorie and **Don Webster**; Sibyl and **Ralph Fletcher**.

We heard from 70 other classmates who will not or cannot attend. As usual, **Rudy Gruber** will be in Germany enjoying his birthday with family and friends at about the same time as our celebration at Chatham. . . . From **Victor Dunbar**: "No doubt you already realize that I will not be able to attend our 61st Reunion as I had a slight stroke two and a half years ago. My son and I even had to cancel our Annual Reservations for the Dartmouth College Alumni in August. Over two years ago my son purchased a new country home, which faces exactly south overlooking Bras D'Or Lakes. It is a half hour drive to Cape Breton College where my son teaches and also is in charge of a new department which has emphasis on thinking and less on memory only."

From **Charlie Reed**: "We regret so very much our inability to attend the reunion in June. The early June timing is not right for us, but I understand you can't suit everybody. Although we don't see anything of our classmates during the year, somehow the spirit of comraderie persists and I love to see them at reunion time. As we get older, it seems to me the recollection of the days at M.I.T. get sweeter. I did return to Tech in Cambridge in 1923-24, but it is the days on Boylston St. in Rogers and Walker, tough as they were, that I like to think about most, and also the afternoons out in Brookline at the track field, learning how to broadjump and trying to beat Wilson and Wilkins in the 100- and 220-yd. runs and the Guethings in the quarter- and half-mile. Those moments were certainly a switch from analyt, calculers, and the Theory of Mechanical Similitude." . . . From **Val Ellicott**: "Your announcement about reunion has come, but I am sorry to say that there is very little chance of my getting to reunion in June. If things change, I will let you know". . . . From **Paul Austin**: "I am now what I call 'semi-retired.' I am waiting for business to pick up at Arthur G. McKee & Co. in San Mateo. When it does they will call me back to my job in the piping section, and I will be very happy. For me, retirement is 'for the birds.' "

We heard from **Maury Holland** on his 86th birthday. He had been in Florida for the winter and was getting things lined up for his annual check up. Also, we had word from **John Fairfield**: "No news here; a bit more tottery and willing to let the world wag." . . . **Hank Smith** wrote: "I would like very much to be able to join the group at the reunion in Chatham. But at the present time I just don't know if I can make it; and so it will be about the first of May before I know what my activities will be for the coming summer season." . . . We heard from Isabel and **Ralph Forsyth**: "Ralph just had the battery in his pacemaker replaced, and will be under observation by his doctor for about another month. So we are not planning on returning to the Cape until at least June 12. We are going to miss seeing all the members and friends at Chatham. We'll enjoy reading about it and seeing the picture in the *Review*." . . . From **John Gore**: "Although I won't be there this year, I will be thinking of you and seeing you in my mind's eye. Thanks for putting the article about my wife in the *Review*. It was a beautiful tribute to my wife."

We regret to report the passing of our classmates **Percy Peters** on April 21, 1977, **James Murdough** on March 11, 1977; **Ed Jenkins** on April 16, 1977; **Eugene J. Barney** on January 9, 1977; and **Elmer M. Wanamaker** on January 22, 1977. May they rest in peace! Keep your letters coming, and as **Cy Guething** says so well, "Keep Breathing." — **Ralph A. Fletcher**, Acting Secretary, West Chelmsford, Mass. 01863

17

With so much in the mill with our 60th coming up there is little else to write of at this time. Everything seems to be under control. **Tubby Strout** is getting good response for Chatham Bars Inn and a good campus gathering is anticipated. There have been regrets from **Ned Sewall**, **John Batschy**, and **Howard Hutchinson.**

Dad Wenzell came to town in March with his attractive grandson Stuart Wenzell, who is interested in entering M.I.T. a year from this fall. They met with Pete Richardson, '48, Director of Admissions, and then called on Don Severance '38. The **Dunnings** were guests of the Wenzells for dinner at the M.I.T. Faculty Club where we had a chance to say "hello" to Howard Johnson for a moment. It was all very pleasant, and we are hoping that Stuart will enter the Class of 1982.

Samuel Freed continues to be Treasurer of Central Electric Supply Co. of Worcester, Mass., which is operated by his two sons.

The sympathy of the Class has been expressed to **Dusty Wilson** on the death of his wife, Elizabeth, last January. They had been regular attendants at all of our reunions and will be sorely missed at the 60th.

This is all there is for now but there will be plenty of Reunion news in the October/November issue. — **Stanley C. Dunning**, Secretary, 6 Jason St., Arlington, Mass. 02174; **Richard O. Loengard**, Assistant Secretary, 21 East 87th St., New York, N.Y. 10028

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Our concluding session of the M.I.T. Alumni Seminar Series took place on April 11. The lecturer was John Collins, Professor of Urban Studies at the Sloan School of M.I.T., and former Mayor of Boston. We learned much about the operations of a large municipality, and of M.I.T. studies in this field. In particular, I was impressed with the conclusion that planning the ideal city free of crime, welfare recipients, and other problems was counter-productive. The reasoning is that such a city would be a magnet to which people living elsewhere under substandard conditions would move.

In my year-end greeting to all, you were invited to look back to 1918 and ahead to the future. Among some of your responses (I hope many of you will follow this example) I present herewith this most interesting commentary from **Chuck Simpson**. I wish I could print it in its entirety.

"You have produced the results you asked for '. . . some news from an elder stateman — looking back at life to 1918 and looking ahead.' To begin with — I'll look back a bit. In doing so I'll warn you now. It's going to be fun . . . because its something new to me. New, because up until now I have *never* looked back. I tried it once serving under General Pershing in Mexico and came within an eyelash of having my head knocked off. Since then I've protected my head.

". . . First, I am forever proud of having been a student (although a very poor one) at M.I.T. starting at the time when I applied for a job with the western division of the American Bridge Co. In a brief interview with the general superintendent he asked me what school I last attended. I proudly said, 'M.I.T.' He hired me, sending me to an erection job at Gary, Indiana, with this parting shot. 'I'm hiring you because we need men but I warn you, I'm a Georgia Tech man and we don't like M.I.T. — so — the first chance I get I'm going to see to it that you are fired!' With that I walked out of his office, went to Gary, stayed with the outfit there, and became the youngest erection superintendent they ever had. Obviously, no firing.

". . . Soon the format changed and I was with General Pershing again — winning World War I. I tried but never could get my name in the papers. However, I had one bright and proud moment. That was when I was awarded three stripes as Sergeant of the 1st Section 126th Field Artillery. . . . In between Wars I and II, I seemed to have grown up — and in so doing had much less fun. Just work. Supervised the building of schools, hospitals, theaters, and what have you in Iowa. Bridges in Illinois."

Later Chuck was given a Major's commission in the combat engineers and after many adventures in the South Pacific was honored as a Colonel. He and his wife have lived in Tampa for 33 years where they "enjoy a home, a little money, a good life, many fine friends and good health. Oh yes — and four of the finest grandchildren anyone could be blessed with. . . . Tell me! Stretched out over 82 years — who could ask for more? That's the 'looking back at life' you asked for. Looking Ahead? Who Knows? . . ."

I note with regret the death of **Fred Philbrick** on December 10 last. Fred was one of the most faithful and devoted members of our class and has

served as our treasurer for many years. After a long and successful career with the Gamewell Co., he retired to Florida. — **Max Seltzer**, Secretary, 60 Longwood Ave., Brookline, Mass. 02146; **Leonard Levine**, Assistant Secretary, 534 Washington St., Brookline, Mass. 02146

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John Coldwell writes, "Not much to say except I'm still hanging around. Feeling okay and spend about three months in Lauderdale By the Sea — no hunting or fishing at home in those months. Hope you are well." **Ev Doten** from Detroit writes, "News not at all exciting. I still have my little part-time connection so go to the office a couple of days a week or so. My good friend here, Class of '17, has just written to Chatham Bars for reservations for his 60th reunion. And this reminds us in just two years we will be doing the very same thing. Our best to all."

Herb Duffy writes from St. Petersburg, "There isn't much for me to write about. The only classmate I knew was my brother-in-law **George Inglis**. He hit a good shot on no. 3 green at Tarpon Springs in 1966, fell on his back and died a little while later from a coronary. I live a very humdrum life, play bridge a few evenings every week, bowl four times a week and watch a lot of TV. But I really enjoy every minute. Hate to drive any more but do all the necessary driving. Saw an old classmate, **Phil Rhodes**, on TV's 'I've Got a Secret' show about ten years ago. Am pushing 82 and expect to be around a good many more years."

Mrs. **Besse (Sindler) Fichter** writes from Baltimore, "As to news of myself, I can only report that I am a very inactive retiree. But I do have some active association with M.I.T. as my grandson Louis Bernstein graduates there in the class of 1977."

Edmund J. Flynn writes from Lehighton, Penn., "I really am hard put to send any news that would justify the use of printers' ink. Erma and I are well, ignoring, as most of us must do, the minor botherations incident to advancing age. There is plenty of work around this place to keep us in fairly good shape, and our location is so beautiful that we intend to stay at least while we can handle it as well as we now can. Late in April I expect to be casting flies for the wily trout (the small successes I usually achieve are incidental). By May I should be sailing my boat on a quite-good-sized lake which is but a short piece away, down in the valley. My granddaughter — at college in Vermont — and my grandson — in high school in the Catskills — are both competition skiers, not Olympic material but good enough to garner a trophy now and then. Unlike their grandfather, they are good all-around athletes. Erma and I attend concerts (chiefly the symphony) in Allentown; I usually make meetings at the M.I.T. Club of the Lehigh Valley (of which I am a cofounder), and twice a month I join other oldsters in a luncheon club in Palmerton which has been going for around 50 years."

Chuck Drew called from Bay of Biscayne, Fla., on March 13. His eyes trouble him for driving so he flies from Minneapolis to Florida for four months. He plans a trip to Switzerland with the Kiwanis Club. **Art Ford** wrote from Ridley Park, Penn., "Having been unable to get about very much within the last year and a half, I fall back upon my great failing — namely, the almost overwhelming urge to write. I don't know how much I've already said about my career, but here goes. In 1928 I was quite dissatisfied with my progress in life, so I went back to M.I.T. for a year of graduate work. In 1930 I accepted an assistant professorship at the University of Minnesota, which I retained until 1940. Then, thinking that I ought to get out into the world again, at least for a year, I went to the Naval Aircraft Factory in Philadelphia. With the coming of the war my leave was extended, and the aircraft work was transferred to Johnsville, Penn. I remained with the Naval Air Development Center until my retirement in 1965. The years I spent there were among the happiest in my life, as I became engaged in problems that were so varied that boredom was impossible.

"During the years I have acquired many and varied interests. Although I've always maintained an interest in engineering matters, I dediced that I wanted to try my ability at oil painting. The result is that our house and my daughter's are covered with my efforts. Much is quite poor, but one or two pieces are not half bad. For a long time I have had an interest in serious music and I have made some 50 tapes, ranging from the earliest to the near modern. As time has gone on I have become an almost fanatical convert to Beethoven.

"Of late I am intensely interested in the trend of affairs on our nation and of the world. Particularly I fear the outcome of our very foolish waste of energy. As a mechanical engineer, I find the thermodynamic laws much on my mind. Can we get Congress to repeal them? Ah well; it will soon be over and the world will continue to rotate, with its squabbles, wars, and foolish attempts at betterment."

Fred Hewes from California writes, "Just recovering from an abscessed sebacious cyst on my back. I have been reminiscing about the Advanced Battalion which started in the fall of 1916 under Captain F. B. Downing. Cadet officers included the late H. L. Wirt, '18, and R. O. Lowengard, '17. There was a memorable Easter week in 1917 encamped at the farm of R. E. Tuttle, '17, near Billerica, where we did bridge work, mapping, and dam construction. I've also had thoughts about how much I enjoyed the friendships and workouts at track. Coach Frank Kanalay was so tolerant and would not drop you from the squad provided you reported regularly and did the prescribed work."

William J. Leahy, who resided in Randolph, Mass., all his life, died on March 8, 1977, at age 79 after a long illness. He graduated from Stetson School in Randolph, Thayer Academy in Braintree, and M.I.T. (in mechanical engineering). He was Treasurer of the Randolph Cooperative Bank for many years until his retirement in 1966, when he also retired from the insurance business which bore his name. He was a member of Randolph Lodge of Elks and the Knights of Columbus Vera Cruz Council of Randolph.

Harold F. Marshall of Palmyra, N.J., died on November 22, 1976. He graduated in mechanical engineering; in 1923 was Advertising Manager for D.P. Robinson Co., engineers and contractors; from 1924 to 1943 Advertising and Sales Executive for Warren Webster Co. of Camden, N.J.; commissioned as Captain and promoted to Major in the U.S. Army Air Force Materiel Command at Wright Field in Dayton, Ohio. He had a son, James L., who entered M.I.T. in 1945.

Elliot D. May, a mechanical engineer, died at age 79 in Winchendon, Mass., on January 12, 1977. He retired as President of Baxter D. Whitney Co., Greensboro, N.C., a longtime Winchendon firm. He was a former Trustee of Wendell P. Clark Memorial, a former Director of the Winchendon Savings Bank, and a former member of their Kiwanis Club. He also served on the School Committee for nine years. He was a former Deacon, member of Standing Committee and Sunday school teacher at Winchendon's First Baptist Church; a 50-year member and past master of Artisan Lodge AF and AM, and a member of the Royal Arch Chapter R.A.M., American Society of Mechanical Engineers, Society of Forest Products, and the American Society of Tool Engineers. He leaves his wife, two children and four grandchildren.

George Michelson writes a report on the M.I.T. Historical Collections after his return from a trip to Florida where we had lunch and a nice visit. "There is an interesting collection of photographs and memorabilia from the beginnings of M.I.T. The Collections is located in the old General Radio Building where the material is well displayed. However, the only items from 1919 are the 25th Yearbook and the 50th Reunion book — hardly a comprehensive record. As you and I felt, there must be many more items available among us, even if only the photographs of our several reunions available among us."

Paul Sheeline writes from Moors and Cabot, Boston, "I am still active in the brokerage business with a firm in Boston. My son is a Director of Pan American and is Chairman of the Board of Inter-Continental Hotels which is spread all over the world. One grandson is taking his master's degree at Stanford; another is at Tufts; one girl is a junior at the University of Wisconsin; another is a freshman at the University of Vermont; and the baby is in school in Oyster Bay, Long Island. Fortunately, Jean and I seem to be in good health and are now looking forward to the 60th Reunion. **Larry Riegel** and I have been working together on raising funds for M.I.T."

Your Secretary had lunch with **John Stevens** at the Country Club of Florida in Boynton Beach on April 14. Jack looks well and has had a fine winter here. He expected to return to his home in Menasha, Wis., on April 27. Both of us look forward to our 60th in 1979 and suggest that we have it in the Boston area instead of on the Cape as we believe we'd have a larger attendance and that it would be less strenuous. Jack sent his best wishes to the Class. — **Eugene R. Smoley**, Secretary, 50 East Rd., Delray Beach, Fla. 33444

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That tragic plane crash on the Canary Islands on March 27 deeply affects us, because on the Pan Am flight were **Alden ("Dusty") Miller** and his wife Clotilde en route to Los Palmos where they were to board the *M.S. Golden Odyssey* for a 12-day Mediterranean cruise. Quick death came to them both. They were inveterate travelers who loved life and were exceedingly active in their community of Phoenix. Classmates attending our 50th will remember how much the Millers enjoyed that reunion. Dusty was an exceedingly popular classmate and the Class has sustained a heavy loss. The Millers are suvived by two daughters, including Mrs. Robert Jones, 91 Ciderbrook Rd., Avon, Conn. Mrs. Jones has requested that donations to the M.I.T. Alumni Fund would be appropriate in the memory of Alden W. Miller.

An able and distinguished representative of our Class was present at the highly successful and well attended second annual Florida Festival in February — none other than **Ed Burdell**. At this writing we are looking forward to that other alumni gathering in June at Cambridge and shall hope for goodly attendance at this auspicious occasion. In any event, have yourselves a restful and relaxing summer "vacation" and do let us hear of the multifarious activities you pursue. — **Harold Bugbee**, Secretary, 21 Everell Rd., Winchester, Mass. 01890

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M.I.T. Challenge '77 has been successful far beyond expectations. The $500,000 matching pool for increases in Alumni Fund giving this year was used up by the first week in March. As most of you have now heard, another matching pool was announced by the Institute in April when $300,000 was allocated from the estate of **Arthur R. Harvey**. Over a period of years, Art discussed with the Institute the arrangements for a charitable trust, indicated that he wished the assets to come to the Institute unrestricted, so that they would be fully available for some worthwhile purpose. The generosity of alumni in responding to Challenge '77 had resulted in increased giving of more than $1,000,000 by March 28.

Another of our class stalwarts has died: **Dugald C. Jackson, Jr.** on March 17, 1977. Dug entered M.I.T. in our junior year after getting an A.B. degree at Harvard in 1917. He got his S.B. and S.M. degrees in electrical engineering. After graduation he had a distinguished career, largely in the field of education, thereby following in the steps of his illustrious father. He taught electrical engineering at the University of Missouri, Duke University, University of Louisville and the University of Kansas, and was Department Head at the last two. In 1939 he was appointed Dean of Engineering at the University of Notre Dame, but went on a leave of absence in October, 1941, to go back to active duty in the U.S. Army Ordnance

Corps. as Executive Officer, Instrument Division, at the Frankford Arsenal in Philadelphia. He served until September, 1945, and retired from the army with the rank of Colonel. Dug also served in the first world war as a Second Lieutenant, 1917 to 1919, spending seven months in France and Belgium. In 1948 he went to work for the Ballistic Research Labs at the Aberdeen Proving Ground, Md., and became director of the Ballistic Institute which provided science and engineering programs at college and graduate level for the research and development people at the Proving Ground. He served until retirement in 1963, since which time he and his wife Betty traveled all over the world.

Another classmate, **Edward W. Sherman, Jr.**, of West Milford, N.J., died on April 13, 1976. Ed worked for many years for the Delawanna Co. (textiles), and in later years in real estate sales. The deep sympathy of the class is extended to the families of these two men.

Spring, 1977, seems to be traveling time for 1921 classmates, announced by four postcards received by your Secretary. . . . **Helier Rodriguez** wrote that he and Graciela attended the Fiesta in Mexico and afterwards visited the ancient ruins in Yucatan. . . . Ruth and **Irving Jakobson** took an M.I.T. - sponsored tour to Egypt, a "land of terrific extremes from the very ancient to the very modern." . . . Helga and **Jim Parsons** spent a "couple of weeks in medieval France and the Pyrenees, staying mostly at converted chateaux. Quite an experience." . . . **Bob Miller**'s card from Jerusalem, mailed on Palm Sunday, said, "Enjoying a fine three-week trip to Athens, Corinth, Holy Land, Hamburg and West Berlin. My greatest regret is that Helen didn't come along, feeling she was not up to all the walking. There were 53 in our group." — **Sumner Hayward**, Secretary, 224 Richards Rd., Ridgewood, N.J. 07450; **Josiah D. Crosby**, Assistant Secretary for Florida, 3310 Sheffield Cir., Sarasota, Fla. 33580; **Samuel E. Lunden**, Assistant Secretary for California, Lunden and Johnson, 453 South Spring St., Los Angeles, Calif. 90013

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The members attending the Second Florida Festival at Orlando on Saturday, February 19, included **Norman Joy Greene**, **Raye Ellis**, **W. B. Elmer**, **Van Dorn C. Smith**, **F. O. Rickers**, **F. M. Kurtz**, **E. Allan Reinhardt**, **Manuel Shampanier** and **Parke D. Appel**. We hope to discover details of these events from the participants. . . . **Paul S. O'Brien** of Baton Rouge is President of Alcohol Affairs, Inc. (non-profit corp.) and publishes a quarterly journal with a circulation of 12,000. He has also published "I Walk No More In Darkness," his life's story, in a 36-page booklet which is required reading for some students at Louisiana State University. Paul lectures there on alcoholism. . . . **R. A. Stone** and Marian sent a January card from the Royal Viking Sea while sailing through the Panama Canal on their way to New Zealand and around the world. . . . **Warren Schoop** of Zurich, who was with us at the 50th, will not be with us this year because of a trip to India and Nepal via a Volkswagon camping-bus tour. They will go through Austria, Yugoslavia, Bulgaria, Turkey, Iraq, Iran, Pakistan and on to Delhi, Agra and Katmandu. He plans to fly back to Switzerland this summer while his friends drive back by a different route.

Marjorie Pierce is Chairwomen of the Sponsoring Committee for the completion of the Ellen Swallow Richards Professorship. She is planning to be with us as Vice President of our Class to help us all know more about the Historical Collections, Independent Living Groups, and another organization of former women students, i.e. A.M.I.T.A. Marjorie has always kept in close touch with the Institute. She typifies the busy person who accomplishes much, also doing many homes in the $200,000 catagory and keeping 20 or so jobs constantly on her architectural boards. She has designed millions of dollars worth of construction and continues to be more creative and popular all the time.

Our compliments to **Bunt Spalding** at the Spalding Inn Club for the brochure and pictures of the club. **W. Palma Dickerman** recommends the Spalding Inn highly, having been a regular visitor for the past eight years. He will join us in June. **Earl H. Eacker** is working hard for us in Boston keeping up with the financial responsibilities of the reunion. We are also looking forward to visiting with **W. Raymond Hewes** while attending our reunion at Spalding Inn Club.

Charles A. Brokaw hopes to be with us in Cambridge, but must go on from there to visit various families in the East before returning to Denver. He plans to play golf at Brae Burn with **Yard Chittick** and **Bill Russell**. . . . **William B. Elmer** of Andover spent part of the winter at Bradenton Beach and continues to make important contributions in the scientific field of optics. . . . **Norman Joy Greene** spent the early winter at Jamaica, but returned home for Christmas at Newtown Square, Penn. . . . **Oscar H. Horovitz** has had another marvelous winter in Florida, playing his daily game of golf and keeping himself in excellent shape. . . . We will be happy to see **I. R. Loss** and Edith in June and hear about their experiences on the Keys in Florida. . . . It also will be great to visit with Kate and **Mac McCurdy** of Indian Wells, Calif., and Seattle. Mac has been a great alumnus of M.I.T. We are proud to have him represent our Class. . . . **Abbott L. Johnson** has accepted the Chairmanship of our Nominating Committee and will be working hard for us at the reunion. His winter address is Phoenix, Ariz.

We have touched upon only a few of the high points of a lot of news of those who will be able to attend the 55th and will visit more at M.I.T. We will greatly miss those classmates not with us, but hope to hear from you all for future issues of the Class Notes. See you in Cambridge. — **Whitworth Ferguson**, Secretary, 333 Ellicott St., Buffalo, N.Y. 14203; **Oscar Horovitz**, Assistant Secretary, 3001 South Course Dr., Pompano Beach, Fla. 33060

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We are advised that **Ray Holden**, **Earle Griswold**, **Royal Sterling** and **Roland Becker** attended the M.I.T. Second Florida Festival at Orlando on February 19, 1977. . . . **Hugh D. Chase** reports that on a trip to visit relatives and friends in California he called on Edward J. Rhodes, '30. . . . **Ragnor D. Naess** tells us that he is now Founder, Chairman and Consultant of Schroder, Naess and Thomas, Investment Counsellors. He is still semi-active at the firm and has other interests including the piano (classical music), travel, skiing and sailing. . . . **J. A. Elfenbein** is still working on weight and c.g. problems of large cargo aircraft. His computer manufactured and sold by Lockheed Aircraft (see *Technology Review*, March/April 1972, this column) is still an important adjunct to the air-freight industry.

We are indeed sorry to learn of the death of **Robert H. Henderson** of Summit, N.J., on January 26, 1977. Bob received his B.S. and M.S. in electrical engineering at M.I.T. His entire career was with the American Telephone and Telegraph Co., Long Lines Department. At M.I.T. he will be remembered as a member of the Psi Delta fraternity, the Rifle Club, the Electrical Engineering Society and the M.I.T. Signal Battalion. He was active in many community affairs in Summit: Summit Old Guard, Summit Area Association for Gerontological Endeavor, Boy Scouts, Presbyterian Church, and held many responsible positions. He was a member of the Telephone Pioneers of America and the M.I.T. Club of Northern New Jersey.

After a long and distinguished career in chemistry and food technology, **Milton E. Parker** of Barrington Hills, Ill., passed away February 8, 1977. Among his corporate associations were Walker-Gordon Laboratories Co., Philadelphia Dairy Products Co., National Dairy Products Co., Beatrice Foods Co., and Sea Products Corporation of New Bedford, Mass., as President and Director. He held 16 U.S. and two Canadian patents involving food products, chemical products, and processes and control equipment development. He was Professor and Director of the Department of Food Engineering, Illinois Institute of Technology, from 1948 to 1961.

Lastly we are sorry to report the death of **John A. Wineman** of Fallston, Md., September 11, 1975. John prepared at Pennsylvania State College and received his degree with us in mechanical engineering. He married Mary Barnhart of Greensburg, Penn., and they had nine children and 26 grandchildren. He spent his entire career in the U.S. Air Force. — **Thomas E. Rounds**, Secretary-Treasurer, 990A Heritage Village, Southbury, Conn., 06488

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Sadly, we report the passing of **Paul Joseph Cardinal** on March 28, 1977 in Naples, Fla., from a lukemia-type cancer. Paul was a human dynamo in Class affairs for 53 years and President from 1964 to 1969. He was an "idea" man with the executive ability to carry through. A very religious person, he loved his family and 30 grandchildren, and greatly enjoyed association with friends, who relished his dry wit and humor. Always grateful for assistance, your scribe prizes the "Rolls Royce" radio as a memento of our 50th Reunion.

He earned his S.B. in engineering administration and retired in 1963 from Hoffmann LaRoche as Vice President of Industrial Relations after 39 years of service. He was a national officer of the Phi Kappa fraternity, and at the Institute a member of several honorary and professional societies. During his career he was a director and consultant to various nutrition science organizations and the International Executive Service Corporation placing technical administrators worldwide. He also wrote non-technical articles for various publications. To Lorene and the children, please know that we share your sorrow. Our thoughts will be with all of you in the days ahead.

Via the business grapevine, we learn that **Joseph T. Lusignan** has been helping organize, on site, a quality control system for a factory recently built in Turkey. It appears that this assignment was through the International Executive Service Corporation, which recruits volunteer top management talent for overseas duty. "Red" retired in 1970 as senior vice president and director of Ohio Brass after 40 years of service.

J. Adalberto Roig writes that he lost his wife, Saro, from cancer, March 18, 1977, but was pleased to report a nine-month-old grandson as an M.I.T. prospect. . . . Unfortunately, we have similar news from **George Holmes, Jr.** in Paradise Butte, Calif., whose wife, Helen, suffered a fatal acute asthma attack in February, 1977. At that time, George was hospitalized with a ruptured ulcer, which was corrected, but cancels his trip East this Summer.

Phil Blanchard, Class Vice President, has been elected to the M.I.T. Corporation Development Committee for a three-year term. His analysis last November of the income possibilities from the William Barton Rogers Pooled Income Fund definitely determines that many of you could do much better, individually, now, and later for the Institute, by placing many securities in the pool. Immediate advantages are a gift tax deduction and increased dividends for life, then the principal reverts to M.I.T.

Edward C. Haines succumbed to cancer on Christmas Day, 1976, in Morristown, N. J. He gained a Ph D. in Chemistry and during his career was associated with duPont, Wetherall in Camden, and Superior Varnish and Dryer Company, Pennsauken, N.J., becoming a consultant on varnishes. He leaves his wife and three children. — **Russell W. Ambach**, Secretary, 216 St. Paul St., Brookline, Mass. 02146; **Herbert R. Stewart**, Co-Secretary, 8 Pilgrim Rd., Waban, Mass. 02168

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Several letters have been received from classmates during the past month and they are much

appreciated. A newsy letter comes from **Franklin Fricker** in Naples, Fla. He and Dorothy were at Disney World for M.I.T.'s Second Florida Festival. There was a big turnout with excellent speakers. He says, "A special treat was to see **Tom Price** and **Jack Dunbar** and wife Helen again." He goes on, "On Sunday morning most of those attending the Festival stayed over to be guests of Tom Jones, '50, who heads Disney World's utility and energy systems. We rode in open-air trams for miles, viewing the facilities behind the scenes that support the Wonderland of Disney World and the projected development of the area. This was of special interest to those of us who have had technical interests. Another break in our Florida life came in January when we took a quick trip to Rio de Janeiro. We joined a charter group from Davidson College, where I took an A.B. degree in 1921. It was our first experience of this kind, in contrast to the tours we have taken in the past. If you have the vigor to stand the excessive crowding, the charter is great, for it stretches your travel dollar more than 100 per cent. Our DC-10 was loaded to the gills, with some 380 souls, representing three or four college groups and the medical societies of North and South Carolina. A very elite group, we thought. As for Rio, it is a fabulous place. We recommend it highly, including the miles of back-to-back bikinis on the beaches that decorate the same." He found the Naples winter a little on the cold side but only twice did he cancel his regular day of golf because of cold weather. Normally he plays three times a week, some times with Dorothy if she is willing to let her art and sewing classes or other activities be pre-empted by golf. Both of them work at the local hospital as volunteers one day a week. Franklin is loud in his praise of the community hospital in Naples.

A letter from **Kamy Kametani** enclosed a fine color photograph of himself and his wife taken on May 8, 1976, their golden anniversary. Kamy reports that all of Japan was hit by severe cold weather this past winter with plenty of snow. But, as of March 17 (the date of his letter), he expected to soon see the cherry trees in blossom.

A note from **Ed Murphy** states his intention to take off for Florida after completing a series of medical treatments which include anti-coagulates among six other medications. By that time he hopes to have something more to report to us, in addition to telling about his trip to Ireland in September, 1976.

From **Roger Ward** comes news that he is writing a book which when published he feels sure will rate him a bid to appear on the Johnny Carson Show — or maybe the Gong Show.

I am sorry to note the passing of **Raymond F. Taylor** at his home in Woonsocket, R.I., on November 23, 1976. — **F. Leroy (Doc) Foster**, Secretary, 35 Woodlandway, P.O. Box 331, North Chatham, Mass. 02650

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In late March six of us got together in **Bill Meehan**'s office at the University of Massachusetts, Boston campus. In addition to Bill and your secretary there were **Pink Salmon**, **Don Cunningham**, **Bob Dawes** and Jacqueline Findlay of the Alumni Office. After stuffing ourselves with some oversize sandwiches provided by Bill, we went to the projection room to view our 50th Reunion videotape. Many of you saw some of it at Chatham, but it is complete now and much of the background noise has been eliminated. It appears that we have something — or will when it is edited. Parts, especially the Technology Day Luncheon at the Cage, are too long, too distant and not '26-related. But edited, it will be a nice addition. The **Shepard** and **Mancha** banjo duet on the beach is a priceless part as is **Morris Minsk**'s solo. Now guess who was elected to edit the tape? My friends agreed that since **George Smith** knew so many of the class, he should do it, so he will. It will be laborious but a labor of love.

I've been back once to talk with their video engineer and the equipment available for the final editing at U. Mass. is what you might expect at

Hisako and Masaru Kametani, '25

CBS or NBC — a computer no less. The operator sits and punches keys and it all happens. To get to that stage, the computer will put numbers on each frame of the two hours of tape indicating hour, minute, second and frame number. I will be provided with casettes which I can use on a specially equipped TV set at M.I.T., and hopefully be able to sift out what should stay and where we can dub things in. That's where the excitement enters because they showed us that color slides can be melded into the tape via a couple of slide projectors. The audio visual camera is limited by the length of the wire but my camera was roaming all over the place and luckily it contained Kodachrome. I've already written to **Al French**, **John Jacob** and **Cesar Canals** to make sure that I had identified their wives properly. Fortunately I had. In addition to slides, hopefully we can dub in sound tape. You will recall that **Ray Mancha** brought his tape recorder to our 50th and his wife has sent us the tapes. We have yet to listen to them but hopefully they can become a part of this videotape record of our 50th. I hope I haven't bored you with the details, but the potentiality for a permanent and meaningful record of our famous get-together has me all excited. It also represents a rather substantial investment from our small class treasury, so I really wanted you to know what is happening. It will be a while before you hear more, so keep your fingers crossed while I tackle something about which I know nothing.

At the request of Dick Knight, '47, Secretary of the Alumni Association, we will list each month missing '26 Alumni. If you know anything about any of them, please drop a note to me. This month's lost classmates are: **Herman Berlin**, **Louis Berube**, **Richard A. Butler**, **Kuang Ming Chang**, **Charles J. Clark, Jr.**, **Hillis R. Clark**, **Daniel J. Collins** and **Frank Cortese**.

Having used up the '26 allotment of space, all I can say in addition is that this has been written while a northeast storm beats heavily against our sliding Thermopane doors. The Vigoro is being well washed into the lawn if not into the sea. With a Cherrio! we will hustle this into the noon mail. — **George Warren Smith**, Secretary, P.O. Box 506, Pigeon Cove, Mass. 01966

27

You will be reading these class notes just after the Reunion. As this is written, in late April, prospects are for a good representation — well over 100 classmates have signed up, with more than half expecting their wives to join them. The report on the Reunion will have to be deferred to a fall issue. Four classmates attended the Second Florida Festival in Orlando in February: **Howard Ferguson**, **Bud Fisher**, **Elwood Church**, and **Sam Auchincloss**. . . . **Carl Redd** has been serving as the "Civil" member of the Maryland State Board of Registration for Professional Engineers for the past year, with four more years to go in his term. This is an unpaid job, but no sinecure; much hard work is involved in ethics hearings relating to the Agnew and Baltimore County kick-back cases.

Last fall, Eleanor and **Charlie Smith** spent six weeks in Great Britain, with a tour of the Highlands, and auto trip from Edinburgh to Coventry, a week on a canal boat from Woverhampton to Gloucester on the Severn, a tour of the West Country, and a week in London.

I reported recently on **Erik Hofman**'s illness. It is good to report that he is improving; he is now ambulatory, and able to write. He has moved from the Reservoir Nursing Home and is now at 1 Schoolmaster Ln., Dedham, Mass. 02026. . . . **Carl Wies** has been named Citizen of the Year of the New London Elks Lodge; he has long been active in civic affairs and historical preservation in New London. . . . **Frank Guscio** is continuing active as a consulting professional engineer; he retired from the U. S. Army Corps of Engineers in 1971, after 29 years with the Corps as a civilian engineer and previous experience with the National Park Service and the Port of New York Authority. He is a Life Member of the A.S.C.E.

Henry Crowell, who suffered brain damage last fall from arterioscelosis, died on January 19. He had started out in architecture but then shifted to heating, ventilating, and air conditioning engineering in Philadelphia. He had retired several years ago.

George C. Popps (Papadopoulis) died in January at his home in Chevy Chase, Md. He was a retired structural engineer, and his works included the Hirshorn Museum of Art and the Brazilian Embassy, both in Washington, and many churches. He was born in Piraeus, Greece, and attended the Polytechnical School of Athens, and served as chief cartographer to the Royal Greek Navy before coming to M.I.T. Before forming his own structural engineering company he had worked for American Bridge Division of U.S. Steel, participating in the design of the Empire State Building and the Golden Gate Bridge. . . . **Lenvik Ylvisaker** died last October. Before retirement, he had been vice president for manufacturing of Continental Can. . . . **Neal H. Cargile** passed away December 30, 1976, at his home in Nashville; I have no details. . . . And I have an extremely belated report that the Rev. **George W. Knight** died in 1968. — **Joseph H. Melhado**, Secretary, 24 Rodney Rd., Scarsdale, N.Y. 10583

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While most of us now have been well retired for several years it is somewhat refreshing to find that a fair number of our classmates are still fully and actively engaged in business or profession. One such is **Roland Beers**, recently elected President of Ethan Allen Community College in Manchester, Vt. A news item in the *Bennington Banner* (Bennington, Vt.) of February 14, 1977, carries the story of Roland's new role. Ethan Allen is a small school, facing many of the current day problems of educational institutions. Roland plans to strengthen the school and bring it to an improved independent condition.

Most of us are well aware of **Jim Donovan**'s continued pace as President of Artisan Industries Inc., in Waltham, Mass. At the March meeting of the Boston Section of the American Institute of Chemical Engineers Jim was honored as a special, hardworking, and well loved "old timer." This section of A.I.Ch.E. with the unique subname of "Ichthyologists" conducted its meeting in its accustomed lighthearted manner, and while adhering to this tradition, the sentiments expressed on that occasion were most sincere. Wife Frannie was on hand to hear the well deserved accolades for Jim. . . . **Chuck Topping** is another '28er still well occupied with business. He is borough manager at Swarthmore, Penn. Despite a busy time of it last year, Chuck managed trips to Texas and Illinois for family visits. His son, Tom,

and his family came (from Switzerland?) to Swarthmore for Christmas. . . . **Herm Swartz**, our recent past class secretary also continues without apparent letup in his publishing business in Lexington, Mass. (*New England Construction Magazine*). Wife Dorothy also is busy working toward her doctor's degree. . . . **John Draper**, president of Draper Bros. Co. in Canton, Mass., is another local stalwart still forging ahead. . . . Others that come to mind are **Dave Olken**, **Abe Woolf**, **Bill Hurst**, **Carney Goldberg**, **Dick Rubin**. . . . Anyone else?

Your 1928 50-Year Reunion Committee is now well along with arrangements for the great event that will take place on campus at M.I.T. in Cambridge from Tuesday, June 6, to Sunday, June 11, 1978. The Institute will provide free dormitory rooms for those who wish to stay on campus. Those who prefer can stay at the new nearby Hyatt Regency Hotel (at their own expense). A block of rooms will be reserved for this purpose. A shuttle bus will provide service between M.I.T. and the hotel. Our class reunions have always been outstanding and this is destined to be one of the best. The time is only 12 short months away. Start planning now and be at your 50th! — **Walter J. Smith**, Secretary, 37 Dix St., Winchester, Mass. 01890

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Arthur J. Bearse writes, "It has been three years since my last note, during which time my wife Ruth passed away. I have recently remarried and last summer spent a month in Europe — two weeks in London, where I met **Leo Goldstein** and his wife Eleanor, and two weeks in Vienna with my daughter, Cindy, who is working for her Ph.D. at the University of Vienna. I have a touch of rheumatism which keeps me on the sidelines this winter." **William C. Whiting** believes in being active in retirement. He is involved in community affairs in Hanover, Mass., where he has lived for the past 50 years. He has served on the local school committee, a scout master for 12 years, and a member of the Fire Prevention Committee for Greater Boston. He is also a candidate for a trustee of the John Curtis Free Library. **Ted Malmstrom** and his wife Florence spent their winter in Honolulu, as usual. Florence writes, "We have been here since December 6, and we plan to return home on April 11. We had the most wonderful holiday season. Our younger daughter and family came here from Chicago for Christmas and New Years — our first family reunion in 16 years. We had a big birthday party for Ted — his big one, as he just turned 70 — with our older daughter and our new friends here. We have an apartment right down in the Waikiki area, most convenient with a view of the mountains right before us. Greetings to all and we will see you in the spring."

Richard Piez has written a complimentary note of appreciation, and adds news of himself: "Though I am retired, I have been doing some part-time work for the past year and a half with a little time off for travel. In 1976 we visited the Canadian Rockies and Hawaii, as well as some lesser locations. My work, at present, is largely connected with the coffee-roasting industry where I have had earlier experience."

A sad note comes from **James C. Reddig:** "I lost my wife, Geraldine, to whom I was married for 42 years, on December 28, 1976, to cancer. I will remain in our present home indefinetely. I visited the Panama Canal this past February, where my father worked in 1913 and 1914 as an engineer. I had always wanted to see it, and — judging from the headlines — I thought I'd better get on with it before we give it away. I chartered a Cessna at Panama City and flew pretty much all over the Isthmus area. It's still an impressive engineering achievement!"

Elizabeth (Stephani) McClellan writes, "Having and raising four children during the Great Depression, I never got to practice my profession (architecture) which I studied at M.I.T. except building and designing my own houses. But I do not regret having made that choice and I wouldn't have it any other way as I have a wonderful relationship with my four boys, three of whom live near me; the oldest lives in New York and visits me regularly."

Your Secretary and his wife had a visit with **Hugh Hamilton** and his wife Helen at their plush waterfront home in Boca Raton. Hugh is quite well and his spirits are high. The only problem is that he can't walk, due to a stroke that he suffered about seven years ago. The Hamiltons did not return to their home in Durham last summer, but they are planning to spend a few months in New Hampshire beginning in August.

Our 50th Reunion, which traditionally is the highlight of college reunions, is on the horizon. Only two more years to go, and you ought to know how fast time flies at our age. The committee is hard at work under the able chairmanship of **Jim Fahey**, and the place is chosen. I am sure we will achieve our goal. But Jim needs help from everyone to contact as many of our classmates as possible and urge them to be present at Chatham Bars Inn in June of 1979. — **Karnig S. Dinjian**, Secretary, 10 Ancient Highway, Plaice Cove, Hampton, N.H. 03842

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Every once in a while the job of class secretary yields an unexpected "perk." Recently I received from **Norm Dolloff** an autographed copy of his book *Heat, Death and the Phoenix: Entropy, Order and the Future of Man*, in appreciation of my years as class secretary. As many of you know, Norm was Chairman of the Geology Department at San Jose State. He reports that he still teaches there on occasion. The Dolloffs have one son, David, whose specialty is design and construction of furniture.

Ralph Draut worked for a number of years in the Federal Aviation Agency on the supersonic transport program and retired when the project was terminated in 1971. His first wife died in 1970 and he has since remarried, thereby acquiring "two lovely daughters, two sons-in-law, and three grandchildren, all in one day." His second wife Maxine formerly worked for the Department of Commerce. Ralph and Maxine both enjoy traveling and have made recent trips to Russia, Hawaii, and Scandinavia, as well as visits to their five children. Ralph's visit to North Dakota last year enables him to say that he has visited all 50 of the United States. He still retains a membership in A.I.A.A. and has done several assignments for the society's Washington office, such as reporting on hearings of congressional committees and helping to form a community action committee. He enjoys singing in various choral groups, as well as in the Society for the Preservation and Encouragement of Barbershop Quartet Singing in America. He occasionally attends functions of the M.I.T. Club where he sees **Haskell Small**.

Don Diefendorf is still active in the Diefendorf Gear Corp. as Chairman of the Board. He reports that he is "teaching nepotism I and II to two sons in the business" so that he can spend less and less time at the office. Don has given up most of his social and public service jobs but is still doing repair and maintenance work, as well as dispatching for a volunteer ambulance corps. . . . **Bill Dickerman** has retired after many years with the Lummus Co. as process engineer and sales engineer. He and Marion are living in Manhattan. His hobbies are swimming, power boating and photography.

Fred Dickerman still has the motor home that he built himself from a Dodge van and that he drove to the 45th Reunion. Kay and Fred make Pinellas Park, Fla., their home base and travel in the motor home in the summer. They both sing in the choir and Kay is active in the Women's Society. They are planning a 45-day excursion to Europe and the Middle East this spring, including a visit to the Holy Land. They recently had a visit from **Irvine "Ted" Ross** and his wife who were visiting relatives in Florida. They also keep in touch with the **George Wadsworths**.

Joe Devorss has retired except for some part-time retail selling in a local department store and is living in Falls Church, Va. Joe had a heart attack in January but reports that his recovery has been rather rapid with no crippling damage. He is still interested in amateur radio using the call letters WB4U0Y. Marge and Joe have a son James who is a doctor in Salem, Ore., and a daughter Joanne who is a WAC now stationed in Germany. They recently received a visit from Midge and **George (Jeff) Wyman** who are now living in Florida where Jeff is enjoying his sailing hobby. He went on a deep water cruise in February and plans on doing considerable sailing at Martha's Vineyard this summer. — **Gordon K. Lister**, Secretary, 530 Fifth Ave., New York, N.Y. 10036

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During the weekend of April 16 and 17, Sally and I visited with Jan and **Larry Barnard** at Longboat Key, Sarasota, Fla., and thoroughly enjoyed ourselves. Larry and Jan both seem well and appear to be having a grand time. During the weekend, all of us attended the M.I.T. picnic at Casey Key where we renewed old friendships with Mae and **Art Lappin**, Lillian and **Al Sims** and Freda and **John Tillinghast**. Incidentally, John's address is 4215 Gulf of Mexico Drive, Sarasota, Fla. Al Sims and I also attended the Second Florida Festival in Orlando on February 19. According to the list of those attending, **A. D. Bertolett** and **James G. Torbit** were also there but I couldn't find them.

It was a shock to learn of **Philippe Bonnet**'s death. According to a newspaper article Philippe designed much of the radar which helped bring victory in World War II. In addition to his professional work, Philippe was a tour director for the National Society of Covered Bridges, was a nationally known photographer of rail and street cars and was well known as a performer in amateur productions of Gilbert and Sullivan operattas. Our deepest sympathy to his wife. A note from **Don Loomis**, says: "News of **Bob McKenzie**'s death from cancer in October, 1976 reached me belatedly. Bob's plans to attend the 45th Reunion were thwarted by this illness, and his last days were made brighter by the thoughtful greeting signed by 35 classmates who were there."

Bob Martin writes that his permanent address is in Florida and his summer address is "Highview," Apt. 19, Sandwich, Mass. 02563. . . . Word from **A. Harry Wagner** tells of his retirement in January, 1974, as Chariman of the Board, Southern Brick Contractors, Inc. He has four children, all married, and five grandchildren. In retirement, he is keeping busy as Secretary of the Mason Contractors Association of Richmond and Executive Secretary of the Virginia Concrete Masonry Association. He also keeps busy with his church work "Meals on Wheels" and enjoys furniture repairing and refinishing.

Arthur Sugden reports that he is retired but gives no details concerning himself. . . . Congratulations to **Jim Fisk** on his selection as the

Jim Fisk, '31

1976 Hoover Medalist. His award reads: "Distinguished leader of telecommunications research, development and engineering, and contributor to the public well-being through broad activities in education and public service of both local and national scope. His leadership of the United States Technical Delegation at the Geneva Nuclear Test Ban Conference in 1958 and 1959 was especially noteworthy and effective, supporting mankind's

hopes for avoiding a nuclear holocaust." — **Edwin S. Worden**, Secretary, P.O. Box 1241, Mount Dora, Fla. 32757; **Ben W. Steverman**, Assistant Secretary, 260 Morrison Dr., Pittsburgh, Penn. 15216; **John R. Swanton**, 27 George St., Newton, Mass. 02158

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A most pleasant note from Susanne and **Juan Serrallach** in Benidorm, Spain, relating the good news that they would be at our 45th reunion. That Benidorm postmark brought back very pleasant memories of our 40th in Madrid and the Alicante area.

Harry Shwachman was a recipient of the Chadwick Medal given at the annual meeting of the Massachusetts Thoracic Society, April 15 and 16. The award is given selectively "for distinguished contributions to the study and treatment of tuberculosis and other thoracic diseases." Dr. Shwachman received the Chadwick award because "he has devoted his professional life to the study and care of sick children and to the support and consolation of their families. He is best known for his outstanding contributions to the understanding and management of cystic fibrosis, the most common lethal genetic disease of white people." He has been the recipient of an international award for contributions to cystic fibrosis, and the Borden Award, presented by the American Academy of Pediatrics.

Donald K. Morgan reports recent visits to Mexico and Georgia. . . . Among those attending the Second Florida Festival in Orlando during February was **Theodore R. Heim**.

My most faithful correspondent and reporter, **Jim Harper**, relays the good news that he will be in attendence at our 45th. Unfortunately his wife is not quite up to par and will not be able to accompany him. Jim as you all know has been a regular attendee at most of our reunions. He reports that **Elton V. Buckley**, now living in southwestern Virginia near Danville, has retired from the rubber industry. Elton is justly proud of his four grandchildren, who live in Connecticut. He and his wife hope to make the 45th reunion. Elton's retirement diversions include reading, golf, and working in the yard. Jim further reports that **Howard V. Quigley** has retired from executive directorships of two non-profit firms helping the deaf with technical and innovative procedures. Howard asked especially that Jim pass along his best regards to **Al Dietz**.

I have just received notice from the Alumni Records Office of the passing of **Charles O. Perpall** on August 3, 1976. The sympathy of the Class is extended to Mrs. Perpall and her family. — **John W. Flatley**, Secretary, Apt. 204, 5100 Dorset Ave., Chevy Chase, Md. 20015

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Bender, Draveaux
Brown, Arthur S.
Bryan, Chas. S.
Chepard, Jacques
Coffey, Philip J.
Fisher, Edward
Hollingsworth, Geo.
Irvine, Robert
Klokoff, Ivan
Kohlmann, Gunter
Lamy, James P.
Lloyd, Edward M.
Macy, Robert M.
Medkoff, Efim I.
Merrill, James R.
Morosoff, Sarge M.
Parra, Miguel G.
Perry, Bretton
Pierce, Edgar M.
Pouchcoff, Vasila F.
Rollinson, John
Rowell, Edward S.
Rumazza, Carlo H.
Sah, P. Y. Ben
Shaughnessey, Thos.
Shore, Leo
Shurtleff, Otis
Sieber, Elbert
Siebrecht, William
Thompson, Gordon
Withers, William

The names listed above constitute "Project Search" (name coined by **Fred Murphy**). Briefly, after six weeks of intensive search, we have been unable to find any leads to the location of these classmates. Whether or not you ever heard of any of these men, please spend a few minutes to scour the phone books in your area, phone the Chamber of Commerce, tax collector. . . . We already have tracked down 20 odd of the missing; a fine start.

I wrote better than 49 letters to classmates who live near the last known addresses of the missings, and the response was most encouraging. I wish to thank all those who searched for us, most sincerely. Space does not allow me to print all the names of these fine chaps. However, many of the respondents had added personal messages for the Class.

A note to **Fred Feustal** brought no news of the missing, but a fine comment on personal matters. Some of you must recall that Fred lost his eyesight in 1950, through diabetes, but that has not stopped him. He says that he is semi-retired, working as a part-time consultant for the Fort Wayne City Utilities. Katy and Fred have four kids; their eldest has an S.M. from M.I.T., and a Ph.D. from Princeton. The next one has a Ph.D. from Dartmouth, and the other two have just plain B.S. from Michigan. . . . **Ralph Peterson** sent me the address of the missing Dr. **Almon S. Parker**, and a fine family story. Most of Ralph's work has been with two large corporations: developing communications equipment for the Signal Corps, producing flight simulators for the Air Force, and for the last few years he has been working for the Department of the Army on non-nuclear systems. Retirement is set for 1978, when he will get to work on projects that have been held in reserve for just this time. His wife's name is one I love, Henrietta, and they have one married daughter, who has five children, and from them, Ralph and Henri have two great-grandchildren. Ralph, you get back to Cambridge June of 1978 for our 45th Reunion. That's an order, haw!

It is inevitable, seeing our long list of lost men, that some may have passed away. This is so. Three of the missing men have passed on: **Dana D. Corrough**, Col. **Isaac H. Ritchie**, and **Robert L. Dunleavey. Morris Guralnick** tells us that Col. Isaac Ritchie passed away about three years ago. Robert L. Dunleavey passed away June 28, 1972, per his brother, Thomas. As usual, no details. Two more of ours are, though not dead, might be so classified; I found no classmate living anywhere near where Col. **Leonard Morrison** had lived in Mansfield, Conn. So I wrote to a long-time friend, Dr. W. Allan Cowan, at the University of Connecticut, and asked him. I got a phone call from Professor Cowan, saying that he had known the Colonel, long divorced through a chronic alcoholic problem, and that the Colonel is now living in the Florida State Mental Hospital, Arcadia, Fla. This is far from good news, with not much to be done. Friends may write, of course. I asked Dr. Cowan why phone 1,200 miles, when 13¢ would do. He said, "Warren, I wanted to hear your voice." . . . **Robert Trimble** is yet another very sad case; one which I have known for about ten years. At that time, I wrote to Robert asking for some class gossip. The reply came from another name, and stated that Robert was a 100 per cent non compos case, and was confined but did not say where. I was asked not to disturb him.

Through **Cal Mohr** we have a message from **Wayne Taul**, of Fresno, Calif. Wayne is still counseling in engineering (all phases), though he is in some trouble with diabetes which holds him back. Wayne is admirably suited for his chosen profession, as he is not only one of ours, but also a graduate of the U. S. Military Academy at West Point. In the note there is one mention of Catherine, Wayne's lovely wife. She wrote part of a letter to me long since. They have one daughter, married to a graduate of the Naval Academy at Annapolis, and who is now a Captain for Western Airlines. Another daughter is married to an M.D. in Cancer Research. Their one son is in management with a big firm in plumbing and industrial supplies; a typical order is for pipe line valves for the Alaska line, at about $5,000,000 — not to be sneezed at. Also from Cal is a shorter bit on **Doug Stewart**, who is in the metal cutting business: sheets of steel, brass, aluminum, etc. Doug and Louise have two girls; one soon to become a lawyer, and the other is even now an author of note. We are sorry to hear that Doug is suffering from an "extensive" case of bursitis; bad, but no details.

I had a fine letter from **Frank Gilmore** (too long

Engineering Shaped More By Need and Less By Feasibility

The progress of engineering assures that its future will be very different from its past, says James B. Fisk, '31, former Chairman of the Board of Bell Telephone Laboratories. Two crucial changes, he told the Engineers Joint Council in San Juan, Puerto Rico, late last winter:

— Engineers are increasingly aware of the results of their work, and they'll be increasingly governed by these perceptions in the future. There are new tools to sense environmental change, new ways to analyze complex interrelationships.

— Because they are more able to deal with complex problems, engineers will become increasingly responsive to the needs and wants of people. "Future technological development may be determined and shaped more by social significance than by technical feasibility," he said.

Dr. Fisk defined the "systems approach" as "a powerful framework and set of formal procedures for considering, and working out, large-scale problems." And he is confident that this approach, "guided by the insights of social science, can assure that technology will be deployed in ways that will benefit the most people at the lowest social, economic, and environmental cost."

But Dr. Fisk warned that to achieve this "engineers will have to know more about the relationship of their work to society — to the environmental, economic, political, and social macrosystems which affect the way large numbers of people live. If engineers don't understand these relationships, or choose to inore them, or fail to raise their voices about them, they will be surrendering their rightful role in the deliberations that will shape our future."

Dr. Fisk was at the Engineers Joint Council's General Assembly to receive the Hoover Medal for "outstanding public service."

to be quoted). Frank retired two years early, from his Professorship at the Cornell Graduate School of Business and Public Administration, and moved to Cotuit, Mass., to a house already rebuilt for retirement use. Mary Lee has joined the Osterville Garden Club and Frank the Centerville Men's Club. (I may have these reversed.) Having been boaters for 20 years, they have a 34-foot power boat, and the house is right on the water's edge. This July they intend to explore the Maine Coast, and come fall they intend to take the boat to Stuart, Fla., and tie her up there for the whole winter, then fly down when possible, to sail and fish. An example of Frank's work at Cornell: they helped G.E. set up its advanced management course at Crotonville, and also worked with I.B.M. and Mobil Oil for ten years. Hot news — a new M.I.T. Club has been formed for all Cape Cod. Many, many thanks, Frank, for your long and fine letter.

We have a good letter from our brand new (almost) Class Agent, **Herbert E. Grier**, We had a rather complete story about this good man, his success in business, and his long history of accomplishments. However, it occured to me that Herb might well have a family life also, and as we are all gossips, I asked him for a few details. Herb allows that a person may retire and still keep just about as busy as before. He illustrates by telling us that he is still on the Board of N.A.S.A. Safety panel involvement, as well as many similar projects of a business nature. He is not loafing, for sure. He and Dorothy have lived in Las Vegas for 25 years, and will, no doubt, continue to do so. Their youngest son, David, attends Harvey Mudd and is a senior this year. He is married, but has no children as yet, is studying pharmaceutical chemistry, and will probably settle in California. Herbert Grier III is 35, and lives in Colorado, where he and his wife and two daughters, own and run a top-notch hardware store. Daughter Joan, married George Arnold, and they have an 18-month-old son. Joan graduated from U.C.L.A. and then went to work for I.B.M. where she teaches computer programming. Many thanks, Herb, for the family story, and you sure ought to be proud of that great group.

Bill Baur sends a Xerox of a letter from an Alumni Association Official congratulating him on the fine job done by him and others for the Central Florida Festival, held earlier in Orlando. The Tampa Bay group hustled over 200 per cent of their quota for the great meeting, and, softly, Bill was the stemwinder. There will be another meeting in Orlando mid-May, after which Bill and Clare take off for Zurich, for a long stay. Now, only incidentally, just two 1933 men showed up for the above festival, Bill Baur, and **Fred Aldridge** from Miami. Not very good, as we have dozens of our class within 50 miles of Orlando.

We have had only one visitor this winter: Roz and **Ellis Littmann**, who dropped in, on leave from the Palm-Aire Spa in Pompano Beach. We had an interesting visit. By the way, **George Henning**'s wife, Lucy, phoned one day telling Leona that she was incarcerated in the same lovely Spa. **Guido Garbarino** and Mary phoned earlier, and this time I talked with this thoughtful classmate. Fran and **Colonel Newton** phoned one day and wanted to visit with us, but, Leona was having one of her poorer days, so it became just a phone call. The Newtons had just returned from a private flight with a friend over part of the Caribbean, and the Windward Islands were mentioned quite specifically. So, it is easy to see that even a phone call ought not to be forgotten, even if a visit is not feasible.

The Fund capsules are a bit short this time; only two. **Charlie Quick** writes that they have purchased a new home on West Grand Traverse Bay, Mich., so now I have to write to see if he has sold the Birmingham home; also if he still owns his Hillsboro Beach Apartment. . . . Here we have the really right kind of fellow, **Carl G. W. Swanson**, who writes that he is working as a volunteer one day per week in the Hospital in Newtown, Conn. His wife, Katherine, also works in the same hospital but has been doing it longer.

Two other fellows have passed away since our last issue. **Ralph L. Garrett III**, passed on March 20, 1977, as reported in the *Boston Globe*. Ralph is described as an insurance man, politician, engineer, and lawyer. At one time he was a Massachusetts State Fire Marshall, and had quite a reputation as an expert. With no details, we find that **William H. Brown**, of Auburndale, Mass., passed away in November, 1976. This delay is always embarrassing. For our class, we will write the survivors of our classmates who have left us.

That's it for this time around, folks. That Project Search (Murphy) really saved me this time, as otherwise the news would look a lot more like most classes, and not like our good one. — **Warren J. Henderson**. Secretary, Fort Rock Farm, Drawer H, Exeter, N.H. 03833

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This month's notes will be primarily an effort to catch up on the collection of Alumni Fund notes that have accumulated. I hope by now you who both "give and write" realize that some of these are squirreled away against the possibility of a news drought.

Al Rogowski tried to quit, but couldn't, as witness: "Thought I retired last May but was called back on a part-time consulting basis dealing with acquisitions, appraisals and siting. Expect to have more time for travel and hobbies during 1977." . . . From Mexico, **Rodolfo Gonzalez Garza** writes briefly, "Enjoying my retirement traveling and attending my private business." . . . One of our seasonal migrants is **Dick Sanders**. He comments that they winter in Vero Beach, Fla., but spend the rest of the time in Annapolis, Md. In between "still flying ourselves around here and there." . . . **John Haines** is getting closer to "that day" as he says, "Betty and I are looking forward to retirement next summer to our new home in Cape Coral, Fla. We expect to spend summers on Chautauqua Lake, N.Y., aboard the 37-foot houseboat I built about 21 years ago." It looks like John has found a way to beat the taxes on a summer home.

More items about retirement. From **Olmstead Wright**: "Retired on August 31, 1976. Now enjoying a life of leisure, but surprisingly no spare time on my hands. Hope to include considerable travel in the future." . . . **Jerry Hudson** is already doing some. He writes, "Living aboard and cruising (and racing) in my sailboat *Fansifree* in the Bahamas, etc., various aspects of oceanography." As a long-time sailor, I have two comments: shame on people who dream up names like that; and as one of a pair of pack rats, how can you ever cut yourself down to what can be gotten on any reasonably sized boat. . . . Finally, **Victor Mooradian** writes, "Have taken early retirement from Englehard Minerals and Chemical Corporation, doing some part-time consulting work in metallurgy and alloy development."

Phil Kron, who is back north again in Fairport, N.Y., sent me a note with a clipping of the death on April 6, of **George R. Struck**, a retired vice president of Eastman Kodak. We had some notes about him when he retired in 1972 when he was manager of the radiography division. . . . John Pitkin, '37, was kind enough to send me clippings from the *Los Angeles Times* of the death of **Benjamin Malin** in the two plane crash in Teneriffe, Canary Islands early in April. He was one of 27 from Leisure World in Laguno Hills who was lost in that tragedy.

On a pleasanter note, six of our class were able to attend the Second Florida Festival in Orlando, Fla., last February. They were **Jack Platt, "King" Crosby, John Dalbora, Richard Miller, Willard Simonds**, and **Henry "Hank" Humphreys**. While in the Florida area I might add that **Phil Kron** said he had avoided the two worst winter months by staying at Hillsboro Beach, but that anyhow, Rochester had not had such a bad time as Buffalo and Watertown.

I think a small disclaimer is warranted about that page I got in the February issue, primarily because it had a rather funny aftermath. One day I got a telephone call from someone in the class of '34 who lives just outside Philadelphia. He said, "I've just been reading in the *Review* about how deeply you're involved in things in Brewster and since my late brother owned some land there, I decided to call you and see if you could help with any information about it." I looked at the latest (January) issue I could find and wondered what in the name of Heaven he was talking about. I looked up what he was after and called him back. Then about three days later I got my February issue, and the light dawned. The all-seeing clipping bureau had picked it up from the local paper and the *Review* staff must have decided to go in business for themselves on '34 notes.

The next set of notes will come to you courtesy of **George Bull**. "This bunch is one more thing out of the way before we leave in a week for six weeks in Italy, Switzerland, France, and England. With my predilliction for railroads and modeling, most of our travel will be by rail and I expect to get to ride some of the restored narrow gauge lines in Wales. The last week, in London, should be fun, a madhouse, or both as it will be the height of the celebrations of the Queen's Silver Jubilee. My only regret is that it will keep me from the July 9 retirement party for **Eric Isbister** from the Sperry Marine Systems Headquarters. Since we met at the pre-freshman camp in 1930 and have been close friends (and for many years worked together) ever since, I'll really miss the party. However, this will not be the end of his associations with Sperry. As far as I know, he will be retained as a consultant." — **Robert M. Franklin**, Secretary, Satucket Rd., Brewster, Mass. 02631; **George G. Bull**, Assistant Secretary, 4601 N. Park Ave., Chevy Chase, Md. 20015

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Bernie Nelson and Rhoda returned in February from a 6,100-mile trip to New York, Virginia, Tennessee, Dallas (for Christmas), Natchez, New Orleans, and Florida. Bernie says, "We saw a number of classmates on the trip. In Dallas we had dinner with Mary Beth Kiebler, widow of **William Kiebler**, who was at our last reunion. In Inverness, Fla., we saw Joe and Larry Sharpe, '36. Larry started with us in '35. Then we saw Priscilla and **Jack Colby**, whom we had dinner with several times. In Ft. Lauderdale, Maggie and **Ed Gregor** met with us. We spent an evening with Betty and **Leo Beckwith** at Palm Beach, talked to **Randy Antonsen** in Washington, and saw Joe and **Don Gittens** on Long Island."

Miscellaneous newsbits: **Lars Ekwurzel** and **Reid Ewing** attended the Second Florida Festival in Orlando on February 19. . . . **Hugh L. McMath** retired from the University of Texas as Professor Emeritus of Architecture after 44 years. His students presented him with a trip to the major sites in Honduras and Guatemala at a retirement dinner they arranged for him. Several years ago he was made a Fellow of the Royal Society of Arts of Great Britain due to his efforts in developing cultural relations between the U.S. and Mexico. . . . **George C. Morrissette** writes, "Although a graduate in naval architecture and marine engineering, I have been employed as a manufacturing engineer for the past ten years. My son is a Lieutenant in the Navy." . . . **Theodore M. Pomeroy** writes that he is enjoying retirement in Cooperstown, N.Y. . . . **John S. Cort, Jr.** writes that he has retired again and hopes to do volunteer work for SCORE.

I am sorry to report the death of **L. Preston Whorton** in Dallas on January 2. He received his Master's degree in Chemical Engineering with us. Our sympathy goes to his widow.

Hope to see many of you June 10 or on a golf course soon. — **Allan Q. Mowatt**, Secretary, 61 Beaumont Ave., Newtonville, Mass. 02160

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News trickles in along with contributions for which both the Institute and I are grateful. **John Rowell** reports from Waterbury, Conn., that he retired as director of engineering at the Anaconda Brass Division of Anaconda in 1973. Since then, until recently, he had been a consultant for Rio Tinto Patino in Cordoba, Spain. Now fully retired he has traveled 18,000 miles touring in the U.S. and

visited his son and family in Sao Paulo, Brasil. . . . **Elliot Cullati** notes that for 26 years he has been president of the J.F. Bingham Manufacturing Company in Lawrence, Mass., and says naught of retiring. . . . **Frederick Watson**, a graduate member of the class retired five years ago as Export Manager in the Plastics Department of DuPont. He winters in the Miami area and summers in Spofford, N.H.

Your secretary stays put at the address below except that between the time this is written and published she will have ventured on a raft on the Colorado through Canyonlands National Park in Utah. — **Alice H. Kimball**, Secretary, P.O. Box 31, West Hartland, Conn. 06091

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Feverish preparations are underway for June of 1978 — 40 years out. Prexy **Norm Leventhal** is spearheading the effort, but where he finds the time I know not. Norm's Beacon Companies are deeply involved among other projects in the new Fiduciary Trust Building in Boston. Norm is a Director of the Massachusetts Bay United Fund, is Chairman of M.I.T.'s Visiting Committee of the School of Architecture and Planning, and will be the new President of the Alumni Association.

If you haven't heard from **Haskell Gordon** yet, you will. Haskell has organized the 40th Reunion Gift Fund, which is moving into high gear.

The third big reunion activity comes under Editor **Ed Hadley**'s direction. Ed's paid ad reads as follows: "*1938 Revisited*, a definitive autobiography of the M.I.T. Class of '38, will be published on or about June 8, 1978, if the editor and publisher ever gets out from under the Technology Day Committee, the Alumni Fund, town activities, and home projects, to say nothing of the work I am paid for. Whether this opus is a worthy successor to *Technique* or a laughable imitation of the *Voo Doo* will largely be up to the readers of these class notes. Eventually we'll send out a questionnaire, asking a number of highly personal, privacy-shattering questions, but in the meantime we need your help for other things. The first item is photographs — from undergraduate days, from the quinquennial reunions, from other get-togethers, perhaps one or two of your family. Write if you have any, and, if you don't mind taking the chance of losing them, send me your glossy prints suitably captioned on the back. The second item is stories and anecdotes from same sources. The third is an offer of actual help. We need both knowledgeable people and people willing to do a small amount of work. The address is G.E. Hadley, 50 Spofford Rd., Boxford, Mass. 01921. Thanks in advance."

Gretchen Birge writes: "For the past five years I have been operating 'Gretchen, Inc.,' a retail shop for decorating, carpet, draperies, etc., in the Town & Country Village Shopping Center in Sunnyvale, Calif. The shop is fun and quite successful. George and I spent five wonderful months with a travel trailer crossing this country and Canada before settling here in Sunnyvale."

Bob Solomon joined the faculty of University of Missouri, Kansas City, as Professor of Pathology. . . . **Clark S. Robinson** writes, "In June, 1976 I retired from the University of Illinois at Urbana and moved to Bozeman, Mont., where I am adjunct Professor of Physics and am occupied mainly with editing and translation of two Russian translation journals in in nuclear physics. I also do a certain amount of hiking, climbing, snowshoeing, and skiing. Classmates and other acquaintances are invited to drop in at our house at 3322 Sundance Rd., Bozeman." . . . **H. J. McGillivray** attended the Second M.I.T. Florida Festival in Orlando last February. Some more of you should plan to attend the third next year. — **A. L. Bruneau**, Secretary, Hurdman and Cranstoun, 140 Broadway, New York, N. Y. 10005

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Walt Mykytow was especially honored by the American Institute of Aeronautics and Astronautics for "his contributions to safety of flight by dedicated technical leadership in prediction and prevention of aeroelastic problems in military aircraft." Walt received a medal and a certificate of citation. Walt is now retired and his career in civil service at Wright-Patterson Air Force Base included pioneer research and many publications on aeroelasticity.

Evan Pancake wrote from Texas and mentioned the current contest between those who strive to keep low price for natural gas and those who seek to raise price to encourage U.S.A. entrepreneurs to find and distribute more of it. Evan is remembered as a great anchorman on our tug-o-war team and we believe his current activities will add weight to the side he advocates in the current energy situation.

Eli Dannenberg and **Ken Madsen** attended a festival in Florida during February. Ken lives in Florida and Eli in Massachusetts. While Eli did not emphasize the point, it turned out then that this trip was not the ideal way for a northeasterner to avoid freezing temperatures that month.

Joe Stoddard wrote from Orlando, Florida that he retired, but does some consulting in mechanical engineering projects.

We were saddened by reports of death of two classmates: **Robert W. Arns, Jr.** of Berkeley, Calif., and Dr. **Harold L. Smith, Jr.** of Rochester, N.Y. There were no details. — **Hal Seykota**, Secretary, 2561 Via Viesta, La Jolla, Calif. 92037

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On Technology Day: June 10, **Thomas F. Jones**, M.I.T.'s Vice President for Research, is moderator for the morning Technology Day program.

In Salem: **James H. Boulger, Jr.**, has been appointed associate member of the Board of Appeal. Mr. Boulger's background is in architecture.

Upward and Onward: **Charles F. De Mailly, Jr.**, is the new products manager for P.C.I. Group, Inc. of New Bedford, Mass. . . . **William R. Stern**, marketing manager with Setra Systems, Inc., since 1970, has been named Vice President, Marketing.

Council for the Arts: Is joining forces with the M.I.T. Leadership Campaign to help achieve the Institute's goals in the arts. Catherine Stratton, Vice Chairperson of the Council, requests help in identifying classmates who are interested in the role that the arts and humanities can play in the education of scientists and engineers, who can play instruments, or who own collections of paintings, sculpture, or books. I suggested **Leonard W. Weaver** of Neponset Choral Society fame. Any others? How about yourself? Write directly to the Council, Room 20D-220.

The Wind and the Sun: **Millard F. Dowell**, of the Erie Section of A.S.M.E., is for the second year the program director for the Erie Engineers' Society Council Winter Annual Meeting. Last year the subject was solar energy; this year it's wind energy. Dowell is at General Electric, involved with jet engines and things aerodynamic. Milt was A.S.M.E. Man of the Year for the Erie Section in 1973.

Alumni Envelope Notes: From Westlake Village, Calif., **Harold D. Hawes**, "My thanks to the Challenger; this provides a great incentive to contribute." From San Antonio, **George R. Weinbrenner**, "Since my retirement from the U.S.A.F. one year ago, I have been busy lecturing at various universities and serving as consultant to the Dept. of Defense on foreign scientific and technical activities." From Santa Barbara, Calif., **William W. Merrill**, "My wife and I spent two months on an American freighter, sailing from San Francisco to the orient between Korea and Indonesia, and returning to Seattle, Wash. A fascinating adventure all the way." From Elk Point, S. D., **Clifford H. Cracauer**, "I've left my position of vice president of Load King Trailer Division of C.M.I. (a business that I managed to increase in size five times and profits ten times in three years) and returned to management consulting with particular emphasis on the very small businessman." From San Juan, Puerto Rico, **Rafael J. Martinez**, "By now most members of the Class of '40 must have amassed enough cash to finance winter trips to P.R. Would love to see any of them when they are down this way."

Oh, To Be in England: **R. Dixon Speas** discussed "The Contribution of General Aviation to Human Welfare and Industrial Development" at the 15th Anglo-American Aeronautical Conference in London, England. The conference is sponsored by the Royal Aeronautical Society. Speas heads R. Dixon Speas Associates in Manhasset, N.Y.

Sadly: It must be reported that **Philip V. Darling**, community planner for the Office of Environmental Policy of the Federal Highway Administration, died March 17, 1977. Darling lived in Annapolis where he is survived by his wife. Darling served the city of Baltimore in several capacities from 1948. In 1965 he became the city's first director of development and represented the city on the Metropolitan Area Council of Governments. — **Frank A. Yett**, Secretary P.O. Box 562, Long Beach, Wash. 98631

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Ivor Collins sent me a *New York Times* clipping headlined, "Mary McGrath Is Bride of **Teddy F. Walkowicz**." It reported the marriage of Mary Lucy McGrath, daughter of Mr. and Mrs. John P. McGrath of New York, to Teddy F. Walkowicz, Chairman and Chief Executive Officer of the National Aviation and Technology Corp.

I talked with **Robert Wallace Blake**, who had just been transfered by Pan Am to be Manager of the Westchester County Airport. Pan Am has contracted to operate the airport. . . . We still receive news of the Loch Ness Monster. Seems our classmates are continuing to be involved. This time it's **Charles Wyckoff**, the photography expert who spent most of last summer "in" the Scottish lake. . . . **Don Scarff** has been elected Chairman of the Pennsylvania Chamber of Commerce and is promoting meetings on energy legislation in Pennsylvania. . . . **Pierre Hartshorne** wrote a long letter from the A.E.C. Laboratories at Los Alamos. Pierre has five sons and is getting ready to retire. He received his 30-year pin the morning he wrote the letter. If you are out that way, he is the only Hartshorne in the phone book.

Calvin Mohr, '33, sent a clipping on **Howie Samuels** which noted: "Talking about his own future, Samuels said he doesn't intend to make another try for New York State Governor, and doesn't completely rule out the possibility that he would become a member of Carter's staff, but said he doesn't want to move to Washington."

I have seen **Norm Shapira** (Col., U.S. Army, Ret.) serveral times. He is extremely busy as consultant to a number of companies. . . . **Harvey Potcher**, retired from his insurance business and is now President of From Vermont, Inc., R.D. #2 Ames Hill, Box A-7, West Brattleboro, Vt. 05301. It's a mail order firm that sells maple syrups, cheeses, baskets (New Hampshire) and other handcrafted items.

David Jacobson writes that he's practicing architecture as a sole principal, based in Arcadia, Calif., since 1957. He has a branch office in Reno, Nev., and is opening another in Atlantic City. He is primarily designing commercial projects such as condominiums, shopping centers, office, industrial, and medical buildings, hotels, and gaming casinos. He is licensed in 12 states and is currently active in New York, New Jersey, Virginia, California, and Nevada. David writes: "Small office, large projects. I'm happy and healthy (swim every morning). I have six boys, all out of college and working; one son, an architect, runs the Reno office. Our largest current job is the Del E. Webb hotel in Reno, with a $25 million construction cost. My hobbies: working on weekends."

On February 19, the Second Florida Festival was held in Orlando and, according to my notes, the following Classmates attended: **Zack Abuza**, **Donald Dixon**, **Carl Schwenzfeier**, **Harold Radcliffe**, and **Clarence Gunderson**. I understand they all live in Florida.

Ken Spengler writes that he has retired as Brigadier General in Air Force Reserve after 36

years' service (30 years in Reserves following World War II duty). He was appointed by the President to a three-year term as member of the National Advisory Committee in the Oceans and Atmosphere, and he has been Executive Director of the American Meteorological Society since 1946.

Robert Fano was one of nine from M.I.T. honored by the I.E.E.E. with the Institute's Education Medal. Congratulations!

Also of interest is an announcement of the 15th Anglo-American Aeronautical Conference, May 31 - June 2, in London, England. **John E. Steiner** of Boeing Aircraft will talk on "Civil Transport Aviation: Progress and Promise." Keep the news coming; we all look forward to hearing from you. — **Henry Avery**, Secretary, U.S.S. Chemicals, 2863—600 Grant St., Pittsburgh, Penn. 15230

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Mark Kravitz is working full time in his restaurant business — four "Steak Clubs" and five "Steak Outs." Five restaurants are in Connecticut, the others in Amherst, Brattleboro, Kingston, and Armonk, New York. Mark is usually at the Vernon, Connecticut "Steak Out," so stop in and see him.

During the past 30 years, **George Watters** has been in the oil business in Japan, Australia, Thailand, Indonesia and finally in Singapore. He is president of Singapore Petroleum Co., which operates a 65,000-barrel-a-day refinery there. George's oldest son is a manufacturer and exporter of oriental merchandise living in Bali. The rest of the family, wife Judy and two younger children, live in Singapore.

Ed Thode is teaching management at New Mexico State University and doing technical and economic evaluations of solar and geothermal energy. Ed's children are working all over the lot: Karen teaching at a high school in East Corinth, Maine; Stephen is a S.A.C. Crew Commander; Jonathan is with Brown and Root working on a nuclear reactor project in Texas. Ed's wife, Isobel, is an opinion pollster for Louis Harris, Inc. Ed writes that **Emilio Touche** is a respected leader in the fast growing city of Chihuahua, which is Emilio's home town. Ed asks "How many of us are making it out in our old home towns?"

Al Goldis is trying very hard to elect a nonpartisan mayor of New York this November. He has his work cut out for him! Al writes that Marv Epstein, '57 is still at Bell Labs, doing great work. Marv has a program of "inspiring sixth-grade ghetto kids to learn math."

Shep Tyree, still teaching chemistry at William and Mary, says that he is having more fun as a consultant solving practical problems for N.A.S.A. and for the E.P.A. than teaching. Shep and Barbara are now in the Grandparent Club.

Charlie Smith is making eight to ten annual trips to Geneva as the U.S. Employer Delegate to the International Labor Organization. I knew he would get into something else after finishing his term as President of the U.S. Chamber of Commerce. . . . **Warne Johnson** left Allied Chemical sometime ago, became a C.P.A. and is Controller of Archibald and Kendall Inc., a spice processing firm in New York. Warne has heard from **Bill Hense**, who lives in Boulder, Colo. I have no idea what kind of work he does but Warne says that Bill Hense spends lots of time in the mountains. Sounds like a fine arrangement!

Charlie Prohaska joined Dupont in 1951 after getting his Ph.D. at Berkeley. He then worked at Savannah River Plant for 14 years and has been at Seaford Delaware Plant since 1965. Charlie recently sponsored Kahsay Teferi, a youngster who escaped from Ethiopia after the recent coup. The youngster is now a student at Seaford High School and Charlie is in a battle with the U. S. Immigration Service to get political asylum for Teferi. — **Ken Rosett**, Secretary, 191 Albemarle Rd., White Plains, N.Y. 10605

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First, I want to wish all of you a very Merry Christmas and a Happy New Year, for the reason that the last time I attempted to do so in these notes the greetings were edited as being untimely, and I figure that by doing so now I will not be taking any chances. They also edited some stuff I wrote about **Gene Eisenberg** living on Reservoir Road and other humorous tidbits, which I cannot recall at this time, due to my impending senility. I do recall, however, that in April I found myself in Chatham, on Cape Cod, with Class President **Ken Warden** and his lovely wife, Marge, and with my hosts, **J. Francis Hoey, Jr.** and Jean. Mr. Hoey has droped the name "Jim" ever since the change of command in Washington, D.C. My wife, Margot, and the rest of us viewed various and sundry resort hotels on that fair peninsula, and we believe that we have come up with a winner for the 35th Reunion, which will be in June, 1978, if our arithmetic is correct. The name of the place is The Wequassett Inn, in East Harwich, which borders on Chatham. It has lovely little cottages overlooking Pleasant Bay, plenty of tennis courts, and other facilities such as three bars, a pool, and plenty of beach, all of which must wet your appetite already.

Lou Rosenblum, former Class Secretary of 1942, and a friend of so many of our class, sent me some correspondence and clippings about **Hal Gershenow**, who lives in Israel, and who is now known as Haim Gershoni. He is an Associate Professor in Industrial and Management Engineering at the Technion — Israel Institute of Technology, and formerly was General Manager of Klil-Israel Non-Ferrous Industries, and two American companies: Richman Brothers, and Joseph H. Cohen and Sons. The clippings had to do with research on more efficient typewriter keyboard arrangements, which they put through computer paces, using the 27-letter Hebrew alphabet, printed without vowels. Hal wrote Lou that they are starting extensive tests to determine if the proposed Hebrew keyboard really yields material which can be read faster and more accurately, and also that they are waiting to find out whether the new "written" Hebrew proves to be efficient. Lou wrote him back that the systematic analysis that Haim and his colleagues have done may be considered a model for a wide variety of languages and writing forms, and suggested Russian and Arabic as starters. Lou, by the way, is associated with the Graphic Arts Research Foundation, Inc., a non-profit corporation dedicated to the advancement of printing technology.

Last February **Cy Kano** announced his candidacy for the Lincoln-Sudbury Regional School Committee, citing his experiences from one-room schoolhouses in Nebraska to his instructorship at M.I.T. in Aeronautical Engineering, the fact that his wife and daughter are teachers, and that his children went to school in the area. Cy is a principal engineer at Teledyne Engineering Service in Waltham, Mass. . . . **Robert R. Everett**, President of the MITRE Corporation, of Bedford, Mass., is one of the trustees of the newly-formed Solar Energy Research Institute which hopes to locate in Cambridge. . . . I had a good reunion with **James Casserly** at a recent Hartford M.I.T. Club luncheon. He is in charge of marketing of fuel cell operations of the Power Systems Division of United Technologies, in South Windsor, Conn., where he sees **Dick Foley**, also in that division. . . . **Dick Zeamer** wrote that he received his Ph.D. last June in Mechanical Engineering from the University of Utah, and is currently Senior Technical Specialist in flow, heat transfer and dynamics at the Solid Propellant Rocket Plant of Hercules, Inc. at Magna, Utah. . . . **Bill Lacy** and **George Slifer** were at the Second Florida Festival in Orlando in February, along with about 50 other alumni. . . . **John Stetson**, President of A.B. Dick Co., of Chicago, was nominated by President Carter to be Secretary of the Air Force. . . . A Hartford friend of mine conveyed regards from Carmen and **Tony DelValle**, having hosted them at a dinner party in San Juan recently, and reported that they are fine and dandy. I look forward to seeing many of you at the June 10 luncheon on Alumni Day. — **Richard M. Feingold**, Secretary, 779 Prospect Ave., West Hartford, Conn. 06105

44

It's June and we've been to Technology Day at the M.I.T. campus. Since 33 is not an integral multiple of 5, there was no big-deal reunion, but we were glad to see those of our classmates who returned "home" that day. It's also Alumni Association envelope time; please use the information flap and tell us about yourself.

In the news, two classmates: **Kay Kulmala** (you may remember her as Kay Adams in the School of Architecture). She later earned the degree of Master in City Planning which she has put to use in her own firm, the Planning Services Group in Carlisle, Mass. Kay has announced her candidacy for re-election to the Carlisle planning board.

Also in Massachusetts, **Robert O. Smith** of Newton is principal of his own firm which is certainly in tune with the times — specializing in energy conservation and the design of heating systems, conventional and solar. In addition, he has taught at Cornell, Northeastern, M.I.T., and the Boston Architectural Center. Bob was a speaker at a program in February in Fitchburg, a combination of season and city most suitable for his topic.

At the Second Florida Festival in Orlando, also in February, **Paul Fisher** and **Douglas Root** represented the Class of '44.

From the University of Wisconsin (Madison) there is news that **Warren H. Southworth** has been appointed full professor in the School of Medicine. This singular appointment emphasizes the importance of health education in preventive medicine. It may be the very first appointment of its sort.

You may have read in the March/April *Technology Review* that **Herbert L. Carpenter, Jr.**, is now Vice President of Greif Brothers Corp., where he had been Director of Research.

In a pleasant telephone chat with **Don Arsem**, he reminisced about Tech and some people he remembered, **Bob Meny** and **Pierre Boucheron**, for example. **Frank Carroll** is out there in the Chicago area with Don. Two of the next generation of Arsems are back in Massachusetts. A daughter is in M.I.T. administration looking after professorial progeny. A son is pursuing a doctorate in chemistry at Worcester Polytechnical.

We were pleased to attend the Boston Section ceremony at which **Alexander Kusko** (who received his S.M. and Sc.D. in electrical engineering in 1944 and 1951) was made a Fellow of the I.E.E.E. Many of us knew him as a staff member of the Electrical Engineering Department.

Kay Stratton, of the Council for the Arts at M.I.T. has asked to hear from those of our class who are interested or involved in the arts or in the role of arts in the sciences. She would like to know of anyone who owns art collections.

We do not usually identify fraternal affiliations. There has been one exception so far: the "Shaftees," that informal, very involuntary association of M.I.T. men hoodwinked into Army service which (only in retrospect) turned out to be "good old days" for most. Here is another: the 5:15 Club. This was a way station, a home away from home for commuting students. It was really the only campus base for students who lived in neither dorms nor frats. A salute to the paper-bag and milk-carton brigade.

In *Science* for March 18, 1977, there is a comprehensive article by **John G. Linvill** and C. Lester Hogan of Fairchild. The article is on "Intellectual and Economic Fuel for the Electronics Revolution." For "fuel" read "nourishment" and you have a hint of how this article develops its subject. (Dash to your local library; it's worth reading.)

Again we add to this column several more names of alumni from and about whom we would like to hear and whose addresses we cannot find: **Richard Barry**, **Frederick D. Debell**, **Gordon R. Findlay**, **Francis S. Holt, Jr.**, **Deloss Kahl, Jr.**, **Richard S. Livermore**, Mrs. **James W. Orr** (Barbara R. Howe), **Paul D. Wellenkamp**, and **Matthew M. Shapiro**. — **Melissa** and **Newton Teixeira**, Secretaries, 92 Webster Park, West Newton, Mass. 02165

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As you read these notes, hopefully I will have just seen many of you in Cambridge. Perhaps many of you will be enthused or have feelings of guilt and write with some frequency.

The clipping services advise that Armstrong Cork has just appointed **Ted Thomas** to the position of Associate General Counsel for Patent and Trademark Affairs. Ted joined Armstrong as a patent attorney in 1954.

Prudential Property and Casualty Insurance Co. has announced the promotion of **Harold Steiner** to the position of Senior Computer

Harold Steiner, '47

Systems Analyst. Harold and his wife Hilo have four children and will continue to reside in River Plaza, N.H.

Should any of you have a commitment to or sincere interest in the arts, I ask that you write Catherine Stratton, Vice Chairman of the Council for the Arts at M.I.T.

Next edition should have a report of the festivities of our 30th Reunion. — **Dick O'Donnell**, Secretary, 28516 Lincoln, Bay Village, Ohio 44140

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We note the death of **Anita Porell Krause** of Great Neck, N.Y., on December 12, 1976. She leaves her husband Robert and a son Richard, a student at M.I.T. A memorial fund has been set up for the purpose of purchasing a dual chamber incubator for the Immunology Laboratory of the M.I.T. Center for Cancer Research. Please send contributions to the Anita Porell Krause '48 Memorial Fund, c/o Recording Secretary, M.I.T. Room 4-113, Cambridge, Mass. 02139. Checks should be made payable to M.I.T. — *S.K.*

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Slim pickings this month. One Technology Fund news note from **John H. Dalton** who indicates he is Manager, Anti-Submarine Warfare Marketing for Goodyear Aerospace Corporation. A list from Orlando, Fla., indicates that three of our classmates attended the Second Florida Festival there on Saturday, February 19. They were **Parker Painter, Jr.**, **Heber J.R. Stevenson**, and Col. **William S. Hutchinson**. Sorry I didn't know about it since I left Kissimee for Boston one day earlier.

Only two news notes this month: **Robert C. Cowen**, science editor of the *Christian Science Monitor* and a *Technology Review* columnist has been honored by being made a Life Member of the National Association of Science Writers; and **Walter E. Morrow** has been named Director of Lincoln Laboratory effective April 1, 1977, succeeding Gerald P. Dineen, who resigned as director after he was nominated by President Carter as assistant secretary of defense. Walter and his wife Janice live in Weston. They have three children, Clifford, Gregory and Carolyn, who is a junior at M.I.T. His appointment as director is but one more step in his long, productive, and professionally rewarding career at the Lincoln Laboratory since he joined them as a staff member in the Long-Range Communications Group in 1951.

That's all for this month. I hope to have seen some of you at our annual class cocktail party on Alumni Day before these notes reach print. Best wishes to all. — **Frank T. Hulswit**, Secretary, 77 Temple Rd., Concord, Mass. 01742

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Warren E. Ponemon is Chairman and Chief Executive of Autonumerics, Inc., who design and manufacture numerical controls and numerically controlled machine tools.

George W. Santos, Professor of Oncology and Medicine, has moved into the new Johns Hopkins Oncology Center. He is director of the clinical and laboratory program in bone marrow transplantation.

Nathan H. Cook, Professor of Mechanical Engineering at M.I.T. and recipient of the 1977 S.M.E. International Education Award, delivered the keynote address at the 1977 Manufacturing Engineering/Technology Education Forum sponsored by the Society of Manufacturing Engineers in Detroit, Mich , on May 10.

Assessments of contemporary quantitative models of the elements and systems which mediate human manipulation and mobility will be the focus of an Engineering Foundation Conference entitled "Cybernetic Models of the Human Neuromuscular System." The conference will be held in August at New England College, Henniker, N.H. **Robert W. Mann**, Whitaker Professor of Biomedical Engineering at M.I.T., is Conference Chairman.

In attendance at the Second Florida Festival in Orlando on Saturday, February 19, were the following: **W. Stanley Gordon**, **Joseph B. Oppenheim**, **James A. Hooper**, **Harvey "Tom" Jones**, **Robert Mann**, **William Towles**, **David W. Sigourney,** and **Jack Pines**. — **John T. McKenna, Jr.**, Secretary, 2 Francis Kelley Rd., Bedford, Mass. 01730

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Howard B. Zasloff has been promoted to manager, Lummus Technical Center Operations. . . . **Donald Jaffe** is supervisor at Bell Laboratory in Allentown, Penn. Donald's oldest daughter, Nancy, received her master's degree from Columbia University in January, 1977. She was a Wellesley graduate in 1975. Donald also has two children at the University of Pittsburgh, a freshman and a sophmore. Two more of the Jaffe family are still at home with their parents.

In May, 1976, **W. P. Chandler** concluded a three-year stint in petroleum marketing line operations as manager of Sohio's Youngstown division. The division has $80 million in annual sales. Since then, he has been senior licensing manager in the Cleveland head office, and travels the world licensing Sohio's Acrylonitrile ammoxidation process (the leading acrylo process in the world). His daughter, Lisa, graduated in August, 1976, as a Registered Nurse with a bachelor's degree from Syracuse University. She was married shortly after graduation and lives in Syracuse. His son, Jim, is a sophomore at Cornell. . . . **Robert H. Damon** is again swimming in the A.A.U. masters' competition, after a 23-year layoff. Bob was an "also-ran" in five individual events in the August, 1976, Long Course Nationals. He won medals in three relay events. Bob's daughter is at Vanderbilt University studying nursing and his son is studying engineering at Trinity University in San Antonio. His wife, Bobbie, is teaching first grade for her fifth year and is loving it.

Roger R. Borden is both Associate Professor of Mechanical Engineering at Worcester Polytechnic Institute and Pastor of West Fitchburg United Methodist Church. He received his M.A. in Theological Studies from Assumption College in Worcester in May, 1976. His son Andrew, 18, and his daughter Meredith, 13, his wife Connie, and he hope to attend the 25th reunion. . . . **Ralph W. Bell, Jr.** has two new positions at Lakeland Community College in Mentor, Ohio: Director of the Engineering Division, and Director of Continuing Education. . . . **Dana M. Ferguson** and **Gene Becken** attended the Second Florida Festival in Orlando on February 19.

Dick and I hope to see you all and your families at the 25th reunion. — **Arthur S. Turner**, Secretary, 175 Lowell St., Carlisle, Mass; **Richard F. Lacey**, Assistant Secretary, 2340 Cowper St., Palo Alto, Calif.

A Fond Farewell to Kenneth S. Brock

Kenneth S. Brock, '48, who has been at M.I.T. since 1963, first with the Alumni Fund and since 1973 as Director of Resource Operations, has been named Vice President for Development and Public Affairs at the Institute of International Education, New York.

I.I.E. is the nation's oldest and largest international education organization, administering scholarships and grants for over 7,500 U.S. and foreign students each year and arranging other educational exchanges and technical assistance. As its Vice President, Mr. Brock will be responsible for all its fund-raising activities.

In seven years beginning in 1967 when Mr. Brock became its Director, contributions to the Alumni Fund totaled $19 million. Since then he's had "major responsibilities" in M.I.T.'s $225 million Leadership Campaign, where he's performed "outstanding service," says General James B. Lampert, S.M. '39, Vice President for Resource Development.

The picture shows Mr. and Mrs. Brock receiving good wishes from Paul E. Gray, '54 (left), Chancellor, and Mrs. Gray (right) at a reception early this spring. Mrs. Brock holds a Steuben glass beaver, the M.I.T. "mascot," given by colleagues. (Photo: John M. Grunsfeld, '80)

A special nostalgia draws Benjamin Agusta, '52, back to Cambridge for his 25th reunion this month. It was just 25 years ago that he squired his wife Jo, then his fiancee, through Senior Week at M.I.T. They're obviously all ready: the beer mug is 25 years old, a souvenir of Senior Week, and the license plate is brand new, ordered for the occasion.

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Hopefully it will not be too painful for me to remind you that our 25th Class Reunion will be held only a short year from now (i.e., during the long weekend of June 8-11, 1978). Frankly, it hardly seems possible that our class (or most of it) graduated almost 25 years ago; five or ten years ago, maybe — but *not* 25! Organization is now actively underway for a super reunion (to be held on the M.I.T. campus) and is in the capable hands of **Will Spring**, **Dick Lindstrom**, and **George Hegeman** — to be joined, of course, by many other fine helpers.

John Batter has resigned as Class President, and (for reasons both unknown and mysterious) "yours truly" has been entrusted with that responsibility. In the coming weeks, many of you will be called upon to give support to the reunion and I sincerely hope you will be able to join with us in making it a success.

Dick Simmons is heading up the 25th Reunion Gift Campaign, and help on that score is needed too. For those of you who are strapped by college-age children and thus short on funds for the time being, let me point out that you can make a 25th Reunion *pledge* to be paid over the next five years as a less painful way to rather generously add to the 25th Reunion Gift. To that end, I have increased my Alumni Fund gift this year to $200 and have pledged an additional $900 to be spread over the next five years. Hopefully, many of you will be compelled to match or better that offer.

Other news: **Fred Brecher** has now become a principal in the Philadelphia-based architecture firm of Geddes, Brecher, Qualls, and Cunningham. (They also have an office in Baltimore.) . . . Raytheon Corp. announced that **Daniel Brzezenski** is Manager of Applications Software Development for the Patriot aircraft defense system; as such, he is responsible for the development of the tactical and troop proficiency trainer software for the Command and Coordination Group and the Firing Platoon. (The tactical software provides all the functions required for real-time operation of the Patriot system while operational.) Prior to working on the Patriot program, Dan managed the software development plan for Raytheon's contract definition phase of the Ballistic Missile Site Defense System. . . . **Sven Treitel** has been named Research Consultant in the Geophysical Research Division of Amoco's Research Division. Since joining Amoco's Tulsa research lab in 1960, Sven has been involved in mathematical and statistical methods of modeling subsurface geological information to increase the information available from seismic data. Since joining Amoco Sven has published 35 technical papers in the field; the Society of Exploration Geophysicists has recognized his work, with two best-paper awards and one medal; the European Association of Exploration Geophysicists recently named him recipient of the Conrad Schlumberger Award; and he has recently been appointed to the National Research Council's Committee on Seismology.

Apparently **Mandy Manderson** has been enjoying life; he was fortunate enough to avoid part of the "ravages" of winter in Massachusetts by attending the Second Florida Festival in Orlando in mid-February. Tough break, ole boy! . . . **John Meader** was just promoted to Associate Professor at Worcester Polytechnic Institute; he has been a member of the chemical engineering faculty there since 1960 and prior to that was employed at the Army's Chemical Center in Maryland.

That's all. Please write; my mailbox is lonely. — **Martin Wohl**, Secretary, 7520 Carriage Ln., Pittsburgh, Penn. 15221

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Herb Slater has assumed the presidency of the family business — Slater Electric, Inc., manufacturing electrical wiring devices. Herb's brother Tom, a Tech graduate in the Class of 1956, helps Herb run the company. They would be happy if any of our classmates who are building homes would specify Slater products. Herb lives in Old Brookville, Long Island, N.Y., and his business is in Glen Cove. The Slaters have a 6-year-old boy, Joshua. Herb reports recently seeing **Harvey Steinberg**, who is heading up some housing developments throughout the eastern seaboard.

Charlie Shaw is now one of our Continental types. He is with McKinsey and Co. in Paris. Must be great in the springtime, Charlie. **Bill Hartrick** retired from the Army just a year ago and settled in Breckville, Ohio, joining Republic Steel Corp. as a civil engineer for their Cleveland district. Bill supervises major environmental control projects — which didn't exist when he entered the service. **Carl Bartow** is a neighbor of Chuck's in Westwood, Mass. Carl enjoys his position as a manufacturing consultant in Raytheon's Corporate Staff in Lexington. Carl is married and his four children span high school to third grade. Last year, Carl built his own home on the Cape at Mattapoisett. Fun, but he wouldn't go through that again!

Arthur Kaplan has moved himself all the way down to North Carolina; He is with General Electric in Wilmington as a consulting engineer in their nuclear fuel department. He is involved in federal and state licensing and health physics work. As you all know, this is the area receiving the greatest amount of scrutiny these days as our country evaluates nuclear fuel as a substitute source of energy for oil. Arthur enjoys a full life outside of work. He and Edith, Harrison, and Jacky enjoy boating, tennis, and the beach in the good year-round weather in North Carolina.

Fred West has authored a major research paper on the triple star system ADS 14893, published in the *Astrophysical Journal*. Fred is now working on a small publication on the radial velocity of Vyssotsky 767, a red dwarf star. We are glad to see someone put Francis Weston Sear's good work to some use. Our radial velocity analysis is confined to empirical data gathering as we weave along route 128.

Edward Everett Smith has been accepted to the central teaching staff of the University of Mississippi. Ed is a 1959 graduate of that institution's School of Medicine; he assumed his duties as instructor in Pathology at the Medical Center on January 1, 1977, where he was a fellow in Physiology and Biophysics in 1959-1960 and has been Assistant Professor of Physiology and Biophysics.

Alex Dreyfoos reports that he was recently elected to the Young Presidents Organization. He also reports that the TV station that he purchased with others is now doing very well (after a slow start), and they are affiliated with ABC in West Palm Beach. He also reports that their P.E.C. Color Lab is now making laser color internegatives and prints from 35-mm. color slides using a computer-operated three-color laser-illuminated printer that he designed. The system gives extremely high tonal and color quality. They provide the service to professionals and serious amateurs. He presently has a son attending Worcester Poly and a daughter at the University of Southern Florida. Alex, in addition, is a pilot and reports that he is getting much pleasure out of flying. He recently purchased a Cessna 421 Golden Eagle, and he welcomes all of his old friends to look him up when they are in the area of West Palm Beach.

We had a short note from Col. **John Griffiths** indicating he has been transferred to the Office of Assistant Secretary of Defense (Intelligence) at the Pentagon. **Leon D. Michelove** writes that he is a Staff Materials Engineer for the Optical Systems Division of Itek, and he reports that he and his wife, Jacqui, have three children. He is active in Lexington, Mass., affairs and professional societies. **John E. Preschlack** writes in a very enthusiastic note that he is now President of Itek Graphic Products and they introduced a new, low-cost phototypesetter late in 1976 based on the latest microprocesser technology. John reports that 1977 promises to be even more exciting.

Another one of our classmates, **Arthur Coren**, reports that he is President of Zenith Controls, Inc., manufacturers of automatic transfer switches, contactors, and timing controls, and Vice President of Electronic General Systems Marketing Associates. His wife, Judith, is very active in the real estate business and there are two children, Linda, 19, attending Emory University, and David, 15, who professes to be a professional magician. **Arthur W. Haines** reports that he is currently President of the Roseville, Calif., Chamber of Commerce.

Again, we want to thank all of you who have been sending us information to pass on to the rest of our classmates, and we encourage more of you to drop us a line from time to time. Have a happy, fun-filled summer. — **Lou Mahoney**, 14 Danby Rd., Stoneham, Mass., 02180; **Chuck Masison**, 76 Spellman Rd., Westwood, Mass., 02090; **Dave Howes**, Box 66, Carlisle, Mass. 01741

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It strikes me that news items for this column are becoming especially sparse. If there is not an upturn in submission rate, I shall start taking entries from the schools with loyal alumni, like Colorado R and R.

Gilbert Strang, who is a professor of mathematics at M.I.T., has received the 1977 Chauvenet Prize of the Mathematical Association of America for his paper "Piecewise Polynomials and the Finite Element Method," published in the *Bulletin of the Mathematical Society*. The prize was presented January 30 at a meeting of the association in St. Louis. Dr. Strang is chairman of the M.I.T. Committee on Pure Mathematics.

Russell Meyerand has been elected a fellow of the American Institute of Aeronautics and Astronautics. The presentation was made on January 12 in ceremonies at the National Aviation Club, Washington, D.C. He received the honor for outstanding and original work in plasma physics research applied in the fields of electric propulsion, thermionic power generation, space physics, and efforts related to harnessing thermonuclear fusion. Dr. Meyerand joined United Technology Research Center in 1958, and was named Director in 1967.

Blevins C. Dunklin, Jr. is one of the eight community leaders who will be vice chairmen of the Special Gifts division of the Darien, Conn., All-Ages Y.M.C.A. Building fund campaign. He is eastern region manager for Demarche Associates. He is a chartered financial analyst and a member of the New York Society of Security Analysts. He, his wife Edda, and their two children, Annette and Thomas, have lived in Darien for ten years.

Frank B. Leitz, Jr. is giving a paper at the International Conference on Fresh Water from the Sea, which is held this year in Sardinia. He is currently designing equipment for the Bureau of Reclamature's desalination plant at Yuma, Ariz.

Members of the class of 1955 who attended the M.I.T. Second Florida Festival in Orlando on February 19 were: **William M. Crampton, James R. Bartsch, H. Paul Julien,** and **Edmund J. Boyle.**

Lester Lee has progressed from nuclear engineering with Martin Marietta and Hittman Corp. through the wholesale liquor business, real estate, and business sales to his present activities, which are investment management, financial consulting and running a small leasing business. Presently he is planning extended travel for his wife, Ruth, himself, and the children, Robin, Andy and Jennifer. — Send news to: Co-secretaries **Marc S. Gross**, 3 Franklin Ct., Ardsley, N.Y. 10502; and **Allan C. Schell**, 19 Wedgemere Ave., Winchester, Mass. 01890

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Alexander Aitken recently left the Advanced Technology Division of LTV in Dallas, Tex., to start his own engineering consulting firm specializing in computer control applications. . . . **Charles Haase** is an attorney in Colorado Springs, enjoying the skiing and camping opportunities there. He was in an aerospace engineering position with Hughes Aircraft, Potter Pacific and Command Nuclear before entering this new career six years ago. Their two children are now 18 and 20. . . . Dr. **Walter Kuckes** recently completed specialty training in psychiatry and has joined the V.A. hospital system in Minnesota. He has been an M.D. in the Denver area for ten years. . . . **Larry Dodd** has been with Thiokol Chemical in Brigham City, Utah, since graduation. He is a manufacturing engineer in their rocket engine plant. He and his wife enjoy the countryside outside Salt Lake City, and have four children.

Roger Borovoy, our class West Coast Vice President, is also Vice President and General Counsel of INTEL Corporation, the rapidly growing manufacturer of integrated circuits and computers-on-a-chip. Roger had worked at Fairchild in early 60's for Robert Noyce, '53, founder of INTEL. After several years in private law practice he joined Noyce's new firm. . . . **C. Gerald Diamond** was also at Fairchild in the early 1960's before joining Harbridge House Inc, a Boston management consulting firm. After several years there, including 1966 in their German office, Gerry joined Gerry Levine, '51, at Mentor International in San Francisco. In early 1974 he joined the old Fairchild group at INTEL, where he directs the international technology exchange program and other special projects. — Co-secretories: **Bruce Bredehoft**, 7100 Lanham Ln., Edina, Minn. 55435; **Warren Briggs**, 33 Bancroft Road, Wellesley Hill, Mass. 02181

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By the time you read this, our 20th Reunion may be over! How time flies. Here's the last column in my third term (15 years) as your secretary.

Bob Kyser has been elected a principal of Rath & Strong, Inc., a Boston-based management consulting firm with offices also in Chicago and San Francisco. He is an author and speaker to professional societies, a Registered Professional Engineer, a certified instructor by the M.T.M. Association, a senior member of the American Institute of Industrial Engineers, and a Certified Management Consultant. Bob holds an M.B.A. from Harvard Business School. . . . A journal note brings us this biographical information on **Alan Budreau**: "He received the A.M. degree in Medical Sciences from Harvard in 1959. Since 1967, he has been a physicist at the RADC Deputy for Electonic Technology, Hanscom Air Force Base (formerly the Air Force Cambridge Research Laboratories), where he has engaged in research in a variety of microwave acoustics topics. He has more than 20 publications and three patents in this area. In 1976, Mr. Budreau chaired a session at the I.E.E.E. Sonics and Ultrasonics Symposium. In addition to the I.E.E.E., he is a member of Sigma Xi and the Undersea Medical Society."

Charles Feldman is Professor of Biomedical Engineering at Worcester Polytechnic Institute, Vice President for Corporate Development of Electronics for Medicine, Inc. and President of Cardio-Data Corporation of Sudbury, Mass. He is a registered Professional Engineer in the Commonwealth of Massachusetts. Professor Feldman and his associates have pioneered the use of computer techniques for ECG monitoring, and in particular, for detecting ventricular arrhythmias. He has published several papers on the subject of computer applications in biology and medicine and he is currently directing research in the field. . . . **Bob Boese** dropped us a note to say he is now a general and vascular surgeon with offices in Oyster Bay, N. Y., where he has joined the professional corporation of Cooper and Sabini. He is on the staffs of the Community Hospital at Glen Cove and Syosset Hospital and the teaching staff of N.Y. Medical College. . . . **Norman Bryan** sends us the news that he is currently Vice President in charge of Business Development for Greiner Engineering Sciences and located at the firm's home office in Tampa. Norman and his wife, Kathlee, have three children: Wendy (17), Tracy (15) and Luke (10).

There should be a lot of news from the reunion. I look forward to seeing many of you there. — **Fred L. Morefield**, Secretary, Apt. 6A, 285 Riverside Dr., New York, N.Y. 10025

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I'm pleased to report that news of your doings is beginning to trickle in. The world is waiting for even more so please sit yourself down and write to tell what's new.

Pete Buttner is leaving the M.I.T. Dean's Office after nine years for the Sloan School. He is returning to the student body as a member of the Sloan School's year-long accelerated Master's Program. At this time next year he will be, he says, looking for work. . . . **Tom Hastings** is no longer a bachelor, having married Bonnie Selway about a year ago. Bonnie, who is a major feature writer at the *Boston Herald American*, is keeping her given name — something that surely will confuse both postman and neighbors on Spy Pond in Arlington, Mass. . . . **Dick Naylor** remains chairman of the Earth Sciences Department at Northeastern University in Boston. He does come over to the 'Tute frequently for seminars and lab work. Dick is writing an introductory textbook and finding it quite a chore. . . . **Gerald Wilson**, who is a professor at M.I.T., was just appointed Fellow of the I.E.E.E., which is, I gather, quite an honor. His contributions to electrical engineering have been in the field of electric power engineering education and the understanding of arc and noise phenomena in power systems.

Finally I must report that Harvard has finally given me an office of my very own. True, its view is of the adjacent parking garage and true, the secretary is a rather sour sort, but still I take great pride in this status symbol. Since I spend 90 per cent of my time in the lab, the office is only useful to impress visiting firemen. Till next month I am your faithful secretary — **Andrew Braun**, Secretary, 464 Heath St, Chestnut Hill, Mass. 02167

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Eugene Finkin has joined Allegheny Industries as Vice President for Devco, with responsibilities for ventures, new products, and acquisitions. He and his wife and two children are moving to Pittsburgh. . . . **John C. Heine** of Wilmington, Mass., has announced that he is a candidate for the one-year seat on the Wilmington School Committee. . . . **Edward F. Maguire** of Dover, Mass., has become personnel-business manager for the Andover schools. He was previously deputy commissioner of the state department of education and director of management services for the New York Stock Exchange. . . . **Richard A. Crowell**, Senior Vice President and Chairman of the Investment Policy Committee of The Boston Company, Inc., has published a book entitled *Stock Market Strategy* describing modern investment theories and application to personal portfolios. Richard received master's and doctoral degrees in industrial management from M.I.T. and now resides in the Boston area.

Stephen R. Helpern was recently named Vice President-Reinvestments of Consolidated Foods Corp. in Chicago. Steve had been director of acquisitions and prior to that he was a manager in the N.Y. office of Arthur Andersen and Co. In addition to S.B. and M.S. degrees from the Sloan school, he received a Master of Philosophy degree from the Columbia University Graduate School of Business. . . . **Carl I. Wunsch**, a leading physical oceanographer has been named to the newly established Cecil and Ida Green Professorship of Earth Sciences at M.I.T. His specific interests include internal waves, tides, mixing processes, and dynamics of mid-latitude and equatorial circulation. He received the James B. Macelwane Award of the American Geophysical Union in 1971, the Texas Instruments 1975 Founders Prize, and is a full M.I.T. professor. . . . **Don M. Shakow** was named last fall as assistant professor of electronics at Clark University in Worcester, Mass.

David J. Bromer was named to the Watertown, Mass., Housing Authority for a five-year term. He earned S.B., M.S. and Ph.D. degrees at M.I.T. and now works for Gillette Corp. . . . **Tom Burns** and his wife have become excellent marathon runners. Last year his wife Louise ran the Boston Marathon in 90 degree heat and beat half of the women and over 800 men! Two weeks later, on their 12th anniversary they ran the Avenue of the Giants Marathon in California, and that summer they were the first married couple to complete the 26.8 mile Pikes Peak Marathon. . . . **Melvin B. Weiss**, M.D., is on the faculty of the College of Physicians and Surgeons at Columbia University and is now Director of the Adult Cardiac Catheterization Laboratory. . . . **Phil Schmidt** is an associate professor involved in energy conservation at the University of Texas. . . . **Bob Thews** of the Physics Department at the University of Arizona was on sabbatical leave at the Theory Group, Rutherford Laboratory in England. . . . **David Bragdon**, a mathematics teacher at Brunswick School in Greenwich, Conn., was selected last year by the American Bicentennial Academy for inclusion in its register honoring Americans from each of the 50 states.

Robert M.C. Burns is the author of *Home, Inc. The Hidden Wealth and Power of the American Household*, in hardcover and paperback, and also had "America is Going Broke" on Social Security and capital formation published in *Playboy*. . . . **R.B. Stein** spent six years in England and eight years in Canada and is currently in Edmonton, Canada, as Professor of Physiology and president of the Edmonton Figure Skating Club. . . . **Alan Kotok** spent a year teaching in the Computer Science Division at the University of California at Berkeley and has now returned to his position as consulting engineer at the Digital Equipment Corp. in Waltham, Mass. . . . **J.L. Zellers** spent three years teaching physics at the Naval Academy Prep School and is now in personnel assignments at the headquarters of the Marine Corps in Washington, D.C. . . . **Michael Terry** is working on the N.A.T.O. Patrol Ship Project. He and his wife have a son, Ryan and a

Charles Glueck, '62

daughter, Shannon. . . . **Charles G. Glueck, Jr.** was elected assistant vice president of New

England Mutual Life Insurance Co. in Boston. He has research and planning responsibilities and is chairing a special task force for special studies using the computer. — **Jerry Katell**, Secretary, 7 Silverbit Ln., Rolling Hills Estates, Calif. 90274

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Toby Zidle has returned from a two-year assignment in Sydney, Australia, for Atlantic Richfield. He is now with the Geophysical Analysis and Processing group at ARCO's research center in Plano, Tex., (20 miles from Dallas) as a senior geophysicist. The latest addition to the Zidle family, Jonathan Alan, was born February 15, 1977 and he joins sisters Melissa Allison, 6, and Heather Michelle, 2. Heather is an Aussie souvenir.

Bob Osborne was recently appointed Manager of Systems Support and Development for United Computing Systems' Chaska Data Center. As such he will be in charge of all operating system and subsystem design, development, and support. This includes CDC 3300, CDC Cyber and 6600, and PDP 11 computer systems.

Jim Ruttenberg is currently residing in Scarsdale, N. Y., with his wife, Phyllis, and two daughters, Sherrie, 7, and Julie, 4. Jim is the founder of Network Management Associates, a telecommunications consulting firm, specializing in corporate private network design. . . . **Don Dreisbach** is an associate professor of philosophy at Northern Michigan University. He spent the 1975-76 year on sabbatical leave, doing research at the University of Basel in Switzerland. Don is currently working on a book on Paul Tillich's theology.

A short note from **Raphael Solfer** mentioned that his amateur radio call letters have been changed to W2RS. . . . **Douglas Hertz** has been named Assistant Actuary in the Financial Services Department of Massachusetts Mutual Life Insurance Co. Prior to joining Mass Mutual in 1974, Doug was a professor of mathematics at the University of Massachusetts. He is a fellow in the Society of Actuaries. . . . Back in February, **Jim Champy**, attended the Second Florida Festival in Orlando, along with members of other M.I.T. classes from 1955 through 1974.

In the March/April issue of *Technology Review* I reported that **Georges Duval** had changed career directions and was presently studying medicine at George Washington University. This prompted another classmate, **Robert Morse**, to write and relate a similar change of careers. Robert was Course V and XXI at Tech, and Ph.D. in chemistry from Yale in 1966. He followed the traditional route of a post doc (U.C. San Diego) and an assistant professorship (Clark University.) He then made the switch to medicine, graduating from S.U.N.Y.-Buffalo Medical School in 1976 and is now a resident in family medicine at U.C. San Diego. Robert was married in 1966 and has two sons, Justin, 6, and Stuart, 3. In his letter, he wonders how many of our classmates have made career changes ten or more years after graduation. I would say that many of us are doing something other than what we were formally trained for at M.I.T., but very few of us had the intestinal fortitude to actually return to school after a long absence.

Next year at this time we will be celebrating our 15th Reunion. It's not too early to begin thinking about it. Out fifth and tenth reunions were outstanding events — excellent vacations as well as excellent reunions. Plan to take a week's vacation next June. Come to the reunion and spend some time in the Boston area visiting your old stomping grounds. — **Mike Bertin**, Secretary, 18022 Gillman St., Irvine, Calif. 92715

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Greetings '64. We have a lot of good news for this issue, but unfortunately I must initiate the column with news of great sadness. We have lost another classmate. **Lewis R. Wilson** passed away on March 6, 1977. The cause of death was attributed to a heart seizure while he slept. Lew, a brother of Sigma Nu fraternity, had been working for the Vought Corporation as a consultant to the N.A.S.A. Langley Research Center in Hampton, Va. His work in statistical communication theory was creative and the individual to whom Lewis was assigned referred to him as "one of the brighter products of the Institute" in a letter to me. Expressions of sympathy may be addressed to Lewis' mother, Mrs. Ida Mascioli, 833 Elizabeth St., Northbay, Ontario, Canada. Lew is also survived by his 10-year-old daughter Jeanne, who resides with Mrs. Mascioli.

To all of you who continue to support the Institute, please accept my humble thanks. It always gratifies me to receive the contribution envelopes, especially those with the "increased" designation in this year of *The Challenge*. It's all of us that help to keep the M.I.T. experience we so enjoyed available for today's college students with our contributions.

Joseph E. Boling has just moved to Heidelberg, West Germany, where he is assigned to HQ, U.S. Army Europe on the Command Data Base System. Now that all three kids are in school, Louise is working as an R.N. Joe can be reached at Heidelberg (06221) 61711 for those of you in or planning to visit Germany. . . . The **Alan N. Gamse** family is completing renovation and restoration on a 16-room 1857 townhouse in the Bolton Hill area of Baltimore, Md. Their home will be featured on the Maryland House and Garden Pilgrimage this spring, a source of pride for the family, Alan, Barbara, Erin, (9), and McCoy (5½). Al has been especially successful in his law career. Specializing in business litigation and administrative law, he has been a partner in the Baltimore law firm of Semmes, Bowen, and Semmes since March, 1975. . . . **Jon D. R. Gruber** reports that San Francisco and young kids (Lindsay-3½ years, Wyatt-1¼ years) are great. He's still with the firm of Robertson, Coleman, Siebel, and Weisel, providing advice to the big financial institutions on which technology stocks to buy.

Clifford L. Laurence has moved to Aerospace Corporation's Optical Systems Department, where he enjoys working on solar thermal energy systems for E.R.D.A. programs. He and Bette have just moved into a new townhouse near Palos Verdes. . . . **Richard W. Stimets** is (still) teaching physics and doing research in laser physics at the University of Lowell in Lowell, Mass. His highlight of 1976 was a concert tour of England with the Nashua, N. H., Choral Society. Five concerts were given jointly with English choruses in various churches, including Gloucester Catherdral.

Marlene started reporting on a great letter we got from **Jim Lerner** last month. I'm going to save the rest for a "dry month" (one of Jim's motivations for writing was to help me over those "dry" spells) with one exception. **Ron Gilman**, Jim particularly asked for you. I'm sure he'd love it if you, Ron, gave him a jingle at 916-444-6119 (home) or 916-322-6051 (business) or dropped him a line to 1417 18th St., Apartment #2, Sacramento, Calif. 95814.

We have a couple of class heroes this month, though nobody's written a letter. I have exercised secretarial prerogatives (which I hope I have in this regard) and counted the following phone calls as deserving of class hero status.

I spoke with Ellen and **Gary Walpert** last month. Gary was in D.C. on business for a few days and had brought the family along. Our "visit" was limited to a phone chat because I got home late on a Tuesday night from a California business trip of mine and he was returning to Boston early on Wednesday morning. The Walperts are comfortably settled into their home in Weston. Our mutual friend and my neighbor Don Goldman (E.E. '65) confirmed during a visit that Gary was well-adjusted to the role of New England homeowner, which included scaling his roof this past winter to break up ice dams. Gary is enjoying his new position; Ellen is writing, publishing, and enjoying the challenge of two daughters. It was great to hear from them and we hope to be visiting up that way this summer and fall.

Our second "telephone" class hero is the **J. Carl Uhrmacher** family. Carl (Chemical Engineering, S.B., S.M., Ch. E.) is now a Section Manager for Hittman Associates, working on Effluent Guidelines as Consultants to the Environmental Protection Agency (E.P.A.). Ms. Barbara Pollack (Ch. E. '66), also known as Mrs. Uhrmacher, is presently employed as a Manufacturing Engineer (in Hybrid Microelectronics) for the Defense and Electronics Division of Westinghouse. Carl and Barbara will be celebrating their 13th anniversary this fall, just after their son Mark's fifth birthday. The Uhrmachers live in Columbia, Md., where they've been since 1969 when Carl left Exxon (then Esso) and relocated to the Baltimore/Washington area. We hadn't seen them in a long time (about 12 years), but we just finished sharing a delightful family Sunday together and have already planned another one. I'll save some of the reminisces and stories for another issue.

Our family has had an active schedule since the end of February. It got so hectic last month that Marlene not only wrote the whole column (she often helps me with parts of it), but I never even got to see it prior to submission to *Technology Review*. It all started on February 26 when I packed Marlene and the kids off to Florida for nine days of vacation and grandparent visitation. I barely had time to pick them up at the airport on their return and have dinner with them; then I headed out to catch my plane for Lexington, Ky. That was a short trip. However, right on the heels of that one was a ten-day business trip to California. If that wasn't enough, the family drove up to New York for Passover with the other grandparents. I managed to spend the weekend with them before flying back to D.C. for the week's work. The family got home toward the end of the week, just in time for me to leave for a conference in Atlanta (a lovely city). I finally got us all together at home again around April 15. From now on my staff handles the business travel whenever possible (at least for a while). After almost 11 years of marriage, I just couldn't hack it again for almost six solid weeks of bachelorhood. For those of you out there who think it might be great, think twice, think three times; then don't do it. Being at home alone for a while is a great teacher of many of the things we all take for granted. I found I'm accustomed to being alone on the road, but, wow, it's a big empty house when you're there and the family isn't. Enough nostalgia.

I've recently been enjoying a new CB, and I haven't had so much fun since my first Corvette eleven years ago. You can find us as the "Potomac Peasant" or the "Wicked Witch" on channel 19, but we only have one rig so far, so don't expect to catch both of us unless we're together. If you haven't tried it; we recommend it as good clean fun plus plenty helpful when traveling. CBers are good people. I guess that's a big 10-4 for this month. You keep the letters, phone calls, and contributions (they *do* send me the envelopes) coming and I'll do my best to justify your efforts by trying to keep the column interesting and informative. Stay well all and CIAO! — **Steve Schlosser**, Secretary, 11129 Deborah Dr., Potomac, Md. 20854

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Short column this month, all the news coming from the backs of Alumni Fund envelopes. **George Hadley** left the University of Stuttgart last August to return to Seattle. After several months of contract programming, George returned to the fold at Boeing. Befitting a worldly computernik, George owns his own microprocessor, complete with cassette tapes and printer. . . . Sharon and **David Rubin** still live in the new town of Columbia, Md., with sons Ari, 7, and Joshua, 3½. Dave has left the Maryland Department of Transportation after four years there, and now works for COMSIS Corp, a transportation planning consulting firm in Maryland.

Solergy, Inc., the company of **Ronald Smith**, has been awarded a contract for testing of their solar energy collector by the National Bureau of Standards. . . . **John Woods** is now Assistant

Professor in Electrical and Systems Engineering at R.P.I.

Finally, I must note sadly the death of Bruno, our faithful St. Bernard companion of almost ten years. — **Edward P. Hoffer**, M.D., Secretary, 12 Upland Rd., Wellesley, Mass. 02181

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Earlier today, **Ken Browning** called me with some sad and shocking news. **John Mazola** passed away on April 13 while playing racquet ball in California. Apparently, John died of a heart attack. As you probably recall, John played varsity baseball and was captain of the basketball team and continued to be active in athletics, primarily tennis and racquet ball. John's honors are too innumerable to mention, but included the Scott Paper Award as the outstanding Junior Engineering student and a N.C.A.A. Scholar Athletic Award. John had continued for his Master's in Course VI at the Institute. He is survived by his wife, Ann, daughter, Sherry (6), and son, Michael (5). John had been the manager of the Architectural Development Department of the Computer Systems Group at Burroughs' Mission Viejo, California plant. A number of John's fraternity brothers and friends from Sigma Alpha Epsilon were at the funeral including: **Rich Lucy**, **Ralph Schmitt**, **Mal Wheeler**, **Mike Weidner** and **Dave Carrier** of our class, plus Perry Seal, '65, Bob Balacek, '59. I know the entire class joins in sympathy for Jack's family.

Rich Lucy and wife, Pat, have a new son, Robert Sean, who was born on October 7, 1976. Rich recently joined Coldwell Banker, a national real estate services company. . . . **Rich Waterhouse** and wife have a daughter, Judith (12), and a son, Russell (2). He is currently Manager of Product Development for the S.R.A. Communications Division of First Data Corp., a Waltham-based time-sharing company. They specialize in the development of software to aid the design and management of communications networks.

Steve Disman and I were in Cambridge last week on behalf of the New York Alumni Center presenting the Alumni Challenge Cup to M.I.T.'s Heavyweight Crew for their victory over Columbia. It was a fun day and our victory made it all the more enjoyable. — **Paul Rudovsky**, Secretary, 340 East 64 St., New York, N. Y. 10021

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Happy Tenth Anniversary! **Phil Manly** passed the certification exam of the Health Physics Society, thereby becoming the first civilian health physicist in either Hawaii or the national network of shipyards. In addition to heading a training division at the Pearl Harbor Naval Shipyard, Phil has developed a consulting business: Health Physics Associates. He specializes in radiation protection, environmental monitoring, and dosimetry. The local Hawaiian chapter of the Health Physics Society, which Phil helped organize, is planning to sponsor a midyear symposium. In January the Manlys, including Charlotte (9), Fred (7), and Peter (5), spent three days hiking Haleakala Crater on Maui.

John Toivonen is doing postdoctoral research in the Department of Molecular Biology at the University of Wisconsin. . . . **Ernie Ascherman** is president of a small computer firm in Atlanta. . . . **Henry Heines** recently passed the Patent Office exam and qualified as a registered patent agent. He expects to finish law school in 1978 and then take the California bar exam. . . . Happily unmarried, **Eric Rosenfeld** has been with Bose Corp. in Framingham, Mass., since graduation. He is a senior engineer and heads the instrumentation group in the engineering department.

Fred Zoepf returned to Cincinnati after a year and a half in Tennessee. He is working for Procter and Gamble in the area of new plant design. His wife, Janice, earned her J.D. at Vanderbilt and is practicing law with a Cincinnati firm. . . . After a year and a half at Massachusetts General as a postdoctoral fellow, **Mary Heine** is now back at M.I.T. as Assistant Dean for Student Affairs in Counseling with special responsibilities for women students. — **Jim Swanson**, Secretary, 669 Glen Rd., Danville, Calif. 94526

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Welcome, again, from the shores of the Potomac. The big news this month is that our Tenth Reunion committee is off and running with plans for the big event in June, 1978. The committee is led by **Jay Nichols**. **Rick Lufkin**, the publicity chairman, is planning a media blitz that should keep everyone informed of plans. Volunteers are needed to work on the planning. If you are interested please contact Jay (617-861-6228) or Rick (617-235-2195).

Howard Evans received a master's degree in engineering physics from the Air Force Institute of Technology and has been reassigned to the Air Force Academy where he will be teaching physics. . . . **Richard Griggs** is working as a sound recordist in Santa Cruz and is heavily involved in the "new music" scene, performing electro-acoustic music and composing for his own ensemble. He was the associate producer for a low budget feature film, "Off the Wall" which is making the rounds in the festival circuit. . . . **Mike Rodburg** has become a partner in the Newark, N. J., law-firm of Lowenstein, Sandler, Brochin, Kohl, and Fisher. He is involved mainly with the litigation of environmental lawsuits. . . . In a related area, we hear that **Steve Ostrach** is working in the General Counsel's office of the Nuclear Regulatory Commission advising the commission and defending it in court when it gets sued (which is often). He has some responsibilities for the Seabrook, N.H., facility and would be interested in hearing from alumni about that plant or other aspects of commercial nuclear power.

From "snowcovered Columbus, Ohio," we hear that **Barry Mitnick** is still Assistant Professor of Public Administration and Political Science at Ohio State and is writing a book on public regulation. He has gotten interested in antiques and has acquired a roll-top desk once used by the unsuccessful candidate for governor of Ohio in 1887 and later by his son-in-law who was chairman of the same political science department for 40 years. . . . **Jim Just** has moved from MITRE Corp. to the new firm of Donovan, Hamester, and Rattien, Inc. in Washington, D.C., where he is a senior policy analyst doing energy research. Jim and Jan have also bought a new house in the Tyson's Corner area. . . . **Shirley Jackson** has been appointed to the National Science Foundation's Science Information Activities Task Force which has been created to advise the Director of N.S.F.

That's all the news we have for this month. We're looking forward to hearing from you and hope you have a nice summer — **Gail** and **Mike Marcus**, 2207 Reddfield Dr., Falls Church, Va. 22043

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Joe Martin is pround to report that his wife, Cheryl (nee Davidson, class of '72) gave birth to Catherine Marie Martin on November 8, 1976. Martin was with Blue Cross in Chicago and is now in Cincinatti with them; Cheryl was doing structural engineering for Skidmore, Owings, and Merrill.

Gary Astrologes completed his work for a Ph.D. in organic chemistry from the University of Illinois and is now a chemist for Halocarbon Products Crp. of Hackensack, N.J. . . . **John Halperin** finished his second year of internal medicine at the University of Chicago and is heading to Boston to start a neurology fellowship at Massachusetts General Hospital. . . . **Steven R. Cross** and **Dennis A. Cooper** were among the honored guests at the Second Florida Festival in Orlando, Fla. . . . **Art Thrash**, who entered with our class but didn't graduate, has just returned from a six-month trip to Europe where he added to his growing collection of art.

Michael R. Portnoff was selected for the Browder J. Thompson Memorial Prize for a paper he published in the I.E.E.E. Transactions on Acoustics, Speech, and Signal Processing. The February-March issue of *Reports on Research*, an M.I.T. publication, carries an article on his work. Mr. Portnoff will be honored at an April 18 reception along with others such as Dr. Wiesner and Robert M. Fano, '41. Michael is a degree candidate in Course VI.

Please keep your cards and letters flowing in. — **Hal Moorman**, Secretary, P.O. Box 1808, Brenham, Tex. 77833

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It hardly seems possible, but yes, we are to have a reunion this month. Current plans call for a beer blast/rock revival kind of thing Friday night (June 10), various activities such as softball and volleyball on Saturday afternoon, and a harbor cruise Saturday night. All of this should cost about $10, so how can you fail to come?

Duncan Allen has been in Toronto since the fall of '72. After getting a master's in civil engineering (transportation), he started work for a private consulting firm. He has worked with the Toronto Transit Commission and Terminal Railway and has logged over 20,000 train-miles. His wife, JoAnne, finished her M.B.A. at York University, and almost simultaneously gave birth to their first child, a boy. They have been traveling in Europe and in the West.

Paul Lentrichia is a resident in general surgery at Rhode Island Hospital. . . . **Don Coppersmith** is at Harvard working on his doctorate in math. . . . **Richard Pitts** is working toward becoming an actuary here in Massachusetts. . . . **Mark Koenigsberg** is still at M.I.T. in Course XVIII.

Doug Bailey is working at Foster-Miller in Waltham. . . . **Bob Mayer** is a graduate student in physics at the University of Illinois after spending two years as a construction worker in Baltimore. . . . I ran into **Mark Aquino** a few months back. At the time he had one more year at Fort Devens in the army. He and his wife, Susan, had one and a half kids. . . . **Mark Stern** is a medical resident at Long Island Jewish Medical Center after graduating from Mount Sinai Medical School. He and his wife, Jackie have been married four years.

Lenny Sigal is an intern at Mount Sinai in New York after graduating from Stanford Medical. He married Judy Halden last year. . . . **Lee Brown** is also at Mount Sinai after graduating from Mount Sinai Medical School. . . . **Mark Mitchell** is on duty in the Philippines after finishing a tour on the *U.S.S. Aspro*, a nuclear attack submarine. . . . **Steve Goldstein** is a lawyer for Proctor & Gamble in Cincinnati where he lives with his wife, Shelley. . . . **John Bissel** works for I.B.M. at their Federal Systems Division at Cape Canaveral on the space shuttle.

Bill Shields graduated from Columbia Law School and is working for a judge in his home state. . . . **Bob Fourer** is studying Operations Research at Stanford after working for the National Bureau of Economic Research in Cambridge. . . . **Susan Steinberg** and **Elliot Riegelhaupt** were married in November, 1975. Elliot is interning at Montfiore Hospital after graduating from Einstein College of Medicine. Susan is interning at Columbia Presbyterian Hospital after graduating from Harvard Med.

Alfredo Sadun has completed his Ph.D. in neuroscience and will soon finish his M.D. . . . **Pete Sanders** is serving in the Navy. . . . **Eve Sprunt** received her Ph.D. in geophysics from Stanford in January and is continuing there as a research associate. . . . **Bruce Schwartz** is a legal analyst and researcher with the New Jersey Department of Environmental Affairs while finishing law school at Rutgers-Camden at night. "I spend the weeks building up a massive sleep deficit and the weekends trying to recover it," he writes. . . . **Michael Stauffer** recently started work for Syntex Medical Systems in Cupertino, Calif., on computed tomography X-ray body scanners doing two-dimensional signal processing.

Chuck Ward writes, "My wife, Jan, and I finally moved closer to my Wyoming home. We own a six-

acre ranch in Puyallup, Wash., with a couple of head of livestock and a great new job as an environmental research scientist for Weyerhauser. And we had finally acquired some Alpha Epsilon Pi alumni neighbors in California, Kevin and Marsha Treichman, '75, and Roberta and **Mark Linsky**. Guess they'll have to move up here."

Steve Henry writes: "I've just had my appendix removed. After spending three and a half years in D.C., Carol and I finally had a chance to return to Boston. So after being sworn into the D.C. bar in December, I joined Weingarten, Maxham and Schurgin as an associate attorney in the field of patent, trademark, and copyright law. The month before leaving turned out to be hectic. I participated as counsel in my first full-blown patent infringement trial. Also, I was corecipient of the 1976 Robert C. Watson Award of the American Patent Association for the outstanding scholarly paper on the patent system written by students. Our paper, on compulsory patent licensing, is also being cited by E.R.D.A. in their report to Congress and the President on this topic. Shortly before leaving we were visited by **Steve Chessin**. He is working on his Ph.D. in Physics at Berkeley and seems to be enjoying things there. Right now the big event in our lives is house hunting. Our focus is presently on Marblehead, where one deal has already fallen through. Our daughter, Suzanne, was a year old in March and is walking, talking, climbing stairs, etc. With development at this rate, she'll be ready to enroll at M.I.T. next year. But will the Institute be ready for her? By the way, Bill Lee, '71, of our firm is treasurer of the M.I.T. Club of Boston and Buzz Gagnebin, '66, is a director." — **Dick Fletcher,** Secretary, 135 West St., Braintree, Mass. 02184

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The mounds of mail seem to have dissipated since the last issue as your weary hero reports on the latest happenings. **Geoff Churchill** married Kathryn Crosby, Eastern Nazarene '72, on February 12 in Springfield. . . . **Tim Schiller**'s tiddlywinks expertise was duly noted in the Bristol, Conn., *Press* as he prepared for the U.S. winking championship held recently at Cornell. Tim, How'd you do? . . . **Bob Elkin** is still in Minnesota as assistant to the advertising Vice President for the *Minneapolis Star & Tribune*. He will be marrying in June. . . . **John Francis Cavagnaro** is now John Aleksonis Zarkarian (I've known it done), by which name he spent a year at Berkeley in chemistry, then switched to chemical engineering and receiveds M.S.s in both. Jack just passed his prelims and qualifying exams for a Ph.D. and is doing thesis research on spray drying of foods.

Richard Hill writes a long letter. After leaving the 'Tute in '69 due to a lack of motivation, he worked on the TROLL project, and returned to receive his B.S. in Course XVIII with us. Since then he went to Harvard for a Ph.D. in Statistics which he will receive in June. His dissertation is on Robust Regression (excuse me if I got that one wrong). During his schooling he continued to work on TROLL and for the National Bureau of Economic Research as a programmer and in management. He's now with Dynamics Associates, a small consulting company consisting of M.I.T. grads which specializes in software for financial applications. He married Karen Larsen in 1973 whom he met in Watson's anarchy course. She is Wellesley '73 and remains Karen Larsen, a musician who specializes in Early Music (performing music composed prior to 1750 on replicas of those instruments). Karen's instrument is the viola da gamba. . . . Prior to married life, Richard lived in the suburbs. He now owns a two-family house near Fresh Pond and is discriminating against students, etc. Richard and Karen are yearning for life in Europe, trying to escape the northeastern winters.

George Bolen graduates Yale Med in May, along with fellow '73ers **Bill Rea**, **Steve Warsof**, and **Simeon Schwartz**. Simeon and George will intern together on the medical service of New York Hospital in Manhattan. . . . Lt. **Tom Johnson**

Tom Johnson, '73

won the General Foulois award of the Air Force Flight Dynamics Laboratory for "professionalism." . . . **Peter Huber** was appointed assistant professor of mechanical engineering at M.I.T. Peter has been a research assistant and part-time T.A. since 1972. . . . **Tony Scandora** is still working 80 hours a week writing automatic teller software [that Burroughs could do better], and he missed A.L.N.M. for which he will never be forgiven. . . . **Mark Adler** spent some time in Edinburgh, Scotland, doing research in artificial intelligence.

Yours truly has done nothing since the last letter, dated no one of repute; not generally improved his lifestyle one bit. That puts me ahead of the whole '73 Phi Delt house. — **Robert M. O. Sutton**, Secretary, 37 Fairbanks St., Brighton, Mass. 02135

75

My receipt of cards, letters and phonecalls from fellow classmates has been on the upswing lately and I hope the trend continues. Many thanks to those of you who have been in touch.

Ernest C. Brown was recently elected to the Board of Editors of the *Ecology Law Quarterly*, Boalt Hall Law School, University of California, Berkeley. His duties include new topic development, solicitation of authors and book reviews, and establishing contacts with faculty and universities with developed programs in environmental law, science and engineering. Also, he will be the first graduate of the Berkeley joint program in law and engineering, leading to a J.D. in law and M.S. in civil engineering. He invites any reader with an interest in publishing an article on environmental law or policy to contact him at: Ecology Law Quarterly, School of Law, University of California, Berkeley, Calif. 94720.

Beth Karpf writes, "After about a year and a half coordinating projects for the Boston Bicentennial office, I left for Madison, Wisc., where I am now a sales associate for Parkwood Realty Gallery of Homes. I'm also doing a weekly folk and blue grass music show for a local listener-sponsored radio station. I encourage any of our classmates or other alumns who have come to Madison to look me up (particularly if they're thinking of buying or selling a home!)". . . . **Dave Katz** and his wife, Karen, have bought a 60-year-old house in Seattle, Wash. They have been busying themselves with painting, wallpapering, and carpeting and hope to undertake future projects of building a dining room table and planting a vegetable garden. Karen has a new job in personnel for the Kenworth Truck Co., which as of April has positions for about three dozen engineers. So any of you in search of employment might want to check this out.

James P. Demers is in his second year of graduate study at Stanford, "wishing I was back East where the skiing is" (or was, as is now the case.) . . . . Congratulations are in order for **Steve Siesinger** who got in touch to tell me of his upcoming wedding in July.

Hope to be hearing from you. — **Jennifer Gordon**, Secretary, 5 Centre St. #32, Cambridge, Mass. 02139

76

I have a postcard from Tom Openshaw, '75. He still wishes to be considered a member of the Class of '76. Tom has been in Portugal during the last two years doing missionary work for the Church of Later Day Saints. He writes that "the food is great and the people on the whole are hospitable. Finally my Portuguese is fluent. Most people think I am Brazilian, never American." Tom will be back in the States this June.

Cathy Kiselyak has sent me a delightful letter. She and Milton Austin, '75, were married in August. Milton is at Yale Medical School and loves it. Cathy, who chose to retain her maiden name, is "the chief programmer for a prospective reimbursement experiment involving 20 New Jersey hospitals. The experiment is funded by the Social Security Administration in anticipation of national health insurance." Next fall, however, she is leaving the job to enter Yale Law School.

Mark Snyder writes from the Univesity of California at Berkeley, where he is studying biochemistry. His course work is coming to a close, and he is looking forward to doing research. He loves San Francisco almost as much as Boston. As for Berkeley, he calls it "Berserkeley." He says that "all the nuts seem to end up here, especially on and around campus. Actually, many of them are quite entertaining." He also sends greetings from **Stu Morgan**, who is at the San Francisco Art Institute, **Sue Thomas** and **John Williams** both at Hewlett-Packard, and George St. George, '77, at the University of Illinois at Champaign-Urbana. Mark reports that he has spoken with them all recently, and all are doing quite well.

Mike Rucker reports that he has a new job in Fairfax, Va., involving archeology and environmental work. He does mapping and consulting to archeologists and historians in California, Kansas and Virginia. A change from Schlumberger, certainly, and hopefully for the better. . . . **Melissa Weiksnar** has changed jobs. She is now working for an oil company instead of an aerospace firm. The latter did not treat her well, so she left! Going to the former's sponsored school in Bandera, Tex., Melissa reports, was quite an experience culturally. "Everything they tell you about western culture is true: a piano with horseshoe-shaped pedals and a semi-wagonwheel for a music stand. Table lamps were pistols erected on a trinity of horseshoes; floor lamps the same, substitute rifles. Thank God you didn't have to pull the trigger to turn the light on." I hope Melissa recovers from her cultural schock.

From my superagent at the "BagelNosh" (a deli in Brookline) I have gotten some additional news. **Bob Lamb** had decided against treating cows and went to Harvard Med where he gets bull! He can be seen riding the Brighton Center Bus or in the bathroom of building A of the Med School!

Joe Sorge, H.S.T. (Health Science Technology, the joint M.I.T.-Harvard Medical Program), is musical director of "Cramelot," the second-year medical school play. Joe has been seen alive and well and living in luxury, my superagent tells me. . . . **Larry Deckelbaum** (H.S.T.) is worried about seeing the sun this summer. In June he starts hospital work, including dissecting cadavers for pathology.

Bill Phipps is alive, well and healthy at Johns Hopkins Medical. The first term was his good term. He placed biochem because of 7.05 and devoted his time to playing basketball. Second semester, from what I have been told, has not been so pleasant. . . . **John Anderson** got married to Barbara Weiner (Simmons, '77). More details would be appreciated. . . . And rumor, my superagent told me, has it that **Bob Zimmerman** is out of the Navy, married, and has returned to the Institute.

Lastly, **Curtis Menyuk** has changed his graduate study from astrophysics to plasma physics. Why? He says he doesn't want to starve when he receives his doctorate. Don't be afraid to drop me a letter. My eyes and ears can only gather so much information, whereas letters. . . . **Arthur Carp**, Secretary, 67 Badger Cir., Milton, Mass. 02186

Student Financial Aid: The Widening Gap Between Needs and Resources

The cost of attending M.I.T. for an average undergraduate in 1977-78 will be $8,000, not including travel, according to the Student Financial Aid Office; that's the "official" estimate on which loans, self-help, and financial aid grants are computed, and it's up more than 8 per cent from 1976-77 ($7,350).

Part of this increase is the result of rising costs in the Institute dining halls; prices will be up about 6 per cent next fall, says Harold E. Brammer, Director of Housing and Food Services. Another increment is the increase in tuition, from $4,000 to $4,350, announced early this spring (*see March/April, p. A17*). A third is the price of rooms: up an average of 8.4 per cent in the Institute Houses.

Offers of loans and scholarship aid for 1977-78 are based on an "equity" level of $2,500, compared with $2,300 in 1976-77. This is the amount that needy undergraduate students are expected to borrow and/or earn before scholarship assistance becomes available.

"Serious Concern" About "Equity"

Concern over the disparity between student financial aid needs and resources has thus been increased another notch.

Jack H. Frailey, '44, Director of Student Financial Aid, admits that "the increasing cost of attending M.I.T. is greater than the increasing ability of students to pay." The result has been a gradual increase in the number of students receiving financial aid during the last decade, to 62 per cent in the Class of 1980 and to perhaps 65 per cent in the Class of 1981 entering next fall.

M.I.T.'s endowment for scholarships is already substantially inadequate. To maintain present financial aid policies requires all the income from scholarship endowment supplemented by substantial amounts of unrestricted M.I.T. funds. Goals of the Leadership Campaign include $10 million for new scholarship endowment; the Undergraduate Association has urged that this goal be increased to $20 million.

The "equity" level at M.I.T. is now higher — by as much as $1,000, Mr. Frailey thinks — than that of other Ivy League schools with which the Institute competes for students. This means that the price of attending M.I.T. for a needy student admitted to both the Institute and Harvard (or Princeton, for example) may be at least $700 a year in loans — a $2,800 loan burden to repay after graduation.

The Committee on Undergraduate Admission and Financial Aid reported to the faculty this spring its "serious concern . . . about the steady increase in the 'equity' level and the high cost of stabilizing it in the future.

"Endowment income available for financial aid at M.I.T. is significantly less than among our neighbors in most of the Ivy League," Professor Richard M. Douglas, Chairman of the Committee, told the faculty this spring, "and the price of parity in the form of additional endowment funds would be close to $30 million."

New Loans to Middle-Income Parents

Parents of M.I.T. undergraduates may now spread over six years the costs of a four-year college education, making monthly payments on loans which may total as much as $26,000 — $6,500 per year for four years.

The Parent Loan Plan, put into effect this spring, is limited to families whose annual income is between $15,000 and $60,000 —a range which includes the "middle" incomes for which some believe M.I.T.'s present undergraduate financial aid policies are least adequate. The interest rate on outstanding balances is 8.75 per cent —substantially less than is available on personal loans which families might use to accomplish the same goal.

Harvard University pioneered such a "middle-income" loan plan two years ago, and R. Jerrold Gibson, Director of the Office of Fiscal Services at Harvard, thinks it has probably "improved Harvard's yield of students" from such households. "Parent response has been enthusiastic and totally positive," he told Robert M. Wasserman, '80, of *The Tech.*

1,000 "Terrific People" for the Class of 1981

Some 1,900 talented high school seniors were invited this spring to join the M.I.T. Class of 1981; 16 per cent were women, 5 per cent minorities, and 3 per cent from foreign nations (not including Canada). Depending on how many accept — the typical "yield" is between 50 and 60 per cent — other prospective freshmen on a waiting list will also be invited. There were 4,300 applicants, and the goal is a freshman class of 1,000 ready to enter M.I.T. just before Labor Day.

Peter H. Richardson, '48, Director of Admissions, is enthusiastic about the applicants — and about the class. "It's our good fortune — or our problem, depending on which side of the decision you're looking at — to have to turn down some teriffic people," he told the Administrative Council this spring.

Mr. Richardson thinks this year's applicants are more "career-oriented . . . not the risk-takers we saw five or six years ago." Perhaps more conservative, too.

They seem to show more interest in engineering — and especially "an eagerness to apply engineering to real problems" such as the energy crisis, the world food situation, pollution, and overpopulation. But the applicants also showed "some new career directions" — economics and management. Another encouraging sign to Mr. Richardson: a number of applicants "who select M.I.T. as a place to mix science, arts, and sports."

Put Your Name in Room 10-250

Breene M. Kerr, '51, is looking for 450 new chairs for M.I.T.'s new Huntington Hall (Room 10-250). The price is $2,000 each.

A plaque on each chair will identify its donor, and every donor will receive a writing arm from Room 10-250's original chairs — complete with engravings and graffiti from 60 years of use.

"Can you imagine the effect on tomorrow's freshmen when each chair in Huntington Hall will bear the name of its M.I.T. alumnus sponsor?" says Mr. Kerr. "What finer way is there to bring to the attention of all M.I.T. students the fact that alumni are one of the great sources of support of the university?"

The 450 alumni who provide $2,000 each will complete the $1.325 million fund which

The season opened auspiciously for Professor Peter A. Holland, Head Rowing Coach: he's holding the shiny new Alumni Challenge Cup, won on April 16 when M.I.T.'s varsity heavyweight crew decisively defeated Columbia on the Charles. The cup was a project of the M.I.T. Alumni Center of New York, represented in the picture by Paul Rudovsky, '66 (right); in the middle is Mitchell S. Seavy, '77, Captain of the winning crew. Also in the delegation from New York — but not in the picture — was Stephen A. Disman, '66. (Photo: Jet)

is required for the renovation of what Mr. Kerr calls "M.I.T.'s most famous lecture hall" and for the creation of a new Alumni Center on the first floor of Building 10 *(see March/April, p. A21).*

It's M.I.T. Over Columbia, and the New Alumni Cup to the Pierce Boathouse

M.I.T. heavyweight crews made a clean sweep of the Charles River on April 16 opening the 1977 season against Columbia, and the new M.I.T.-Columbia Alumni Cup is now proudly displayed in the Pierce Boathouse.

It was the first awarding of the new cup, a joint project of the M.I.T. Alumni Center of New York and the Columbia Alumni Rowing Committee. Steven H. Disman, '66, S. James Goldstein, '46, and Paul Rudovsky, '66 as well as a delegation of Boston alumni and friends, were on hand for the post-race ceremonies on an unseasonably warm early spring morning. So was William Sanford of the Columbia committee, whose purpose in sharing sponsorship of the cup was to celebrate the 50th anniversary of rowing at Columbia.

M.I.T.'s clean sweep over Columbia included the varsity, the junior varsity, and first and second freshman boats — all in the heavyweight class. Columbia was plagued with problems, and the junior varsity race was stopped when Columbia broke an oarlock 800 meters into the 2,000-meter distance. M.I.T. Coach Peter A. Holland told the officials to halt the race and do it over: "It's no way to win or lose a race because of broken equipment," he said later.

The Day They Found a Planet of Oil

Finish the following science fiction short story — in as many (or as few) words as you want. The winning entry, chosen by four members of the staff of *Thursday,* M.I.T.'s "alternative" newspaper, was to receive two tickets to each of five different Sack Theaters in Boston — a total of *ten free passes.*

It was April, 1990, and time was running out for Earth. Despite the scares of the 70s, the world was still dependent on oil as its primary energy source. Nuclear power had been deemed unsafe for use on the planet itself, coal too polluting. Solar energy was still more of a dream than reality. And only three years of oil was left in the world.

The nuclear disarmament agreement negotiated by Jimmy Carter and Leonid Breznev in 1978 had freed vast resources to the scientific community. Cooperation was the keyword. The World Science Institute, established in 1981 in the Middle East following the fifth and final Arab-Israeli War, had cured cancer in 1984, developed warp drive in 1986, landed a man on Mars in 1987, and sent a crew of 300 to Alpha Centuri in 1988. Yet they could not harness solar power or develop an alternative way to power the world's increasingly technological society.

On the 17th day of the month the message arrived from the Alpha Centuri expedition. "Have found oil. Details to follow." Within 48 hours the entire world knew the news. A planet of pure compressed oil had been found. It would supply Earth for over 5,000 years.

The thirst of Earth for energy sources was so great that not until the 21st was it reported that intelligent life existed on Lifeline, as the planet had been christened.

"Just finish this story and you may have a chance of the lifetime" (sic), said *Thursday.* Though "no promises are being made," *Thursday* said that members of its staff, majors in Course XXI, winners of previous contests, and Harvard students "are probably ineligible."

For the winning entry, see *MIT 77* next month.

Solar Research at a New Cambridge Neighbor

Gloom has given way to optimism: the Northeast Solar Energy Center has moved in at 70 Memorial Drive — literally in M.I.T.'s front yard — and Lawrence Levy, S.M. '48, its Director, says N.E.S.E.C. will ultimately "employ thousands and pour millions of dollars into the New England economy."

Why gloom? Because Mr. Levy and Claude W. Brenner, '47, were the principal architects of a proposal for E.R.D.A.'s Solar Energy Research Institute (S.E.R.I.) to be located in the Boston area. The Energy Research and Development Administration put its S.E.R.I. in Golden, Colo., instead. And then at the last minute it added some "satellite" laboratories, including N.E.S.E.C., and of all those only N.E.S.E.C. has thus far been funded.

N.E.S.E.C.'s assignment, according to Ed Francis, Financial Editor of the *Boston Herald-American,* is to create a solar energy industry. He wrote of studies of incentives, subsidies, and low-cost venture capital to provide seed money. There will be work on how to put new technological developments into the marketplace and how to educate the public on the need for changes in building codes to accommodate solar technology.

N.E.S.E.C.'s staff will soon be built to some 70 people, says Mr. Levy. Already there is "an in-being management team," established to press New England's case for S.E.R.I., says Edward J. King, Executive Director of the New England Council, which coordinated the bid for S.E.R.I.

Colorado Courses from C.A.E.S.

Three video-based short courses made at Colorado State University have been added to the Center for Advanced Engineering Study's catalog. "Engineering Economy," "Quality Control," and "Network Analysis and Design" — each has a study guide with comments, reading assignments, problems, and problem solutions — are now available for rental from C.A.E.S. at Room 9.234, M.I.T.

200 Budding Scientists in the Cage

"Navigational Ability of the Electric Eel (*Sternarchus albifrons*)" . . . "The Prevalence of Coronary Heart Disease Risk Function in an Adolescent Population" . . . "Null Testing for a Paraboloidal Telescope Mirror" . . . "Hyperbolic Non-Euclidian Geometry" . . . "Snythesis and Isometry of Optically Isotropic Bodies" . . .

These were among winning exhibits in the 1977 Massachusetts State Science Fair, cosponsored by M.I.T. and the *Boston Globe* at Rockwell Cage this spring. John Blair, '54, Corporate Director of Research at Raytheon Co., presented Raytheon's scholarship award to David R. Reiser, a senior at Joseph Case High School, Swansea, whose exhibit was on "Medical Applications of Gas Chromatography," and there were nearly a score of other prizes and scholarships, too.

More than 200 winners of local science fairs entered their projects in the 28th annual event. Bruce Catin of Fall River brought a full-size electric automobile which travels up to 80 miles (top speed, 20 m.p.h.) on a single battery charge. How much vitamin C is in fruit juice was the project of Rebecca Hunting of Mahar High School in Orange; next to her was a project to determine the world's most perfect antacid. There were computer programs, solar heating projects, studies of pollution and its effects, even pyramid power.

Goals for Blacks: Power and Pride in Blackness

Why should a black student come to M.I.T.? What should he or she learn?

Science . . . or engineering . . . or management, of course. But that's not enough. He (she) must also learn the system, and how to be innovative within it. Then he will have two powerful tools for advancing the cause of his people.

The message to black students at M.I.T. from Eugene Webb of the Harlem firm of Webb-Brookins Real Estate, Inc., at the M.I.T. Black Students Conference on Science and Technology this spring: "A black student who assumes that he's got it made with a piece of paper he gets from here is wrong. . . . To get ahead in the world out there, to help your people's struggle for equality and justice, to show your pride in your blackness, you must learn . . . how to manipulate the system."

For decades blacks have squandered their opportunities. For example, in all the time of federal urban munificence in the 1960s, when countless urban blacks were summoned to Washington for testimony, hearings, and counsel, there was not a single black travel agency in Boston from which to buy your tickets, said Professor Hubert Jones of the M.I.T. Department of Urban Studies and Planning. A missed opportunity, said Professor Jones — a case in point of how black communities need "to do better at leveraging their resources, combining divided resources into powerful ones."

When you understand the system, you understand that federal manpower training programs are a "hoax," said Professor Jones. That's because "they train people for jobs that don't exist." The real problem is chronic unemployment, the concept that 4 to 5 per cent unemployment — which translates to 15 per cent unemployment among urban blacks and 30 per cent unemployment among black youth — is the best the "system" can do.

New Realism Among the Radicals

The point of this year's Conference was to help blacks at M.I.T. understand the world in which they will live and the real potential of their M.I.T. experience — a guidance conference on what to study and what kind of careers to build, says Mary O. Hope, Assistant Dean for Student Affairs who helped a student planning committee. Two role models were provided by Professor Frank S. Jones, Ford Professor of Urban Affairs, in his major Conference address: Einstein and Ghandi.

Einstein's contribution was that of an intellect — a new understanding of nature and its interrelationships. Ghandi's contribution was in human development — the creation of new opportunities in new communities. Blacks at M.I.T. have a very special opportunity for both — to achieve "an excellence in the marketplace that establishes you as a monopoly" and through this "to do things for the black community that are truly unique."

If it all sounds like radical, new-society oratory, turn back the years by a decade. In 1970 the call was to change the system, even to substitute Ho Chi Minh for Richard M. Nixon. Now there's a new realism: though the system may seem designed to perpetuate black poverty, we can turn it to our good. "The people who built the system are not so clever as they thought," said Kenneth Guscott, a Harlem-based worker in the black cause. "Once you look into the bed, under the blankets, you'll find it's not so hard to make the system work for you." — *J.M.*

The Bell Ringers Head for a Full Peal

After 40 minutes of continuous handbell ringing (in a Building 1 classroom), three members of the M.I.T. Guild of Bell Ringers achieved a "quarter peal" early this spring. Six handbells were involved, each student ringing two; the idea is to progress systematically through all possible sequences of ringing — first 1-2-3-4-5-6, then 2-1-4-3-6-5, etc., making 1,260 changes of sequence.

"Once you've rung a quarter peal you're considered an experienced ringer," says David Westmoreland, '80; "it's one of a ringer's major goals." Next comes a full 5,040-change peal — "four times as long and much more difficult."

O.S. Madsen

Doherty Professorship to Madsen

Ole S. Madsen, Sc.D. '70, Associate Professor of Civil Engineering, is now the third Henry L. Doherty Professor in Ocean Utilization; relieved from teaching duties under the Professorship, Professor Madsen will undertake a year-long investigation of surf zone hydrodynamics on Cape Cod, including both field work and appropriate laboratory experiments.

Before joining the M.I.T. faculty in 1972, Dr. Madsen was with the Coastal Engineering Research Center of the Corps of Engineers in Washington; his research specialties include fluid dynamics, wave mechanics, and sediment transport, and his recent research has made possible prediction of coastal zone sediment movement under conditions of waves and currents heretofore little understood.

I

Civil Engineering

With the Alumni

The "Young Engineer of the Year," selected by the Massachusetts Society of Professional Engineers, is **William F. Callahan,** S.M. '65, a vice president of environmental engineers at Camp Dresser and McKee, Inc., in Boston. The award recognizes an engineer who has been outstanding in service to the engineering profession. . . **Joseph M. Sussman,** Ph.D. '68, has been promoted to full professor in M.I.T.'s Department of Civil Engineering. A specialist in transportation simulation analysis and railroad operations and planning, his current research deals with methods for improving the utilization of freight cars on the U.S. rail network . . . The city of Temple Terrace, Fla., has appointed **Ross T. McGillivray,** S.M. '68, to the city's Engineering Review Committee. He is President and Chairman of the Board of Armac Engineering, Inc. . . . **Edward A. Mierzejewski,** S.M. '71, is currently Chief Transportation Planner at Southeastern Virginia Planning District Commission (Norfolk); he is also a part-time faculty member of Old Dominion University, teaching a course in transportation engineering to C.E. majors . . . **Joseph Penzien,** Sc.D. '50, has been elected to membership in the National Academy of Engineering. . . **Edward R. Ardery,** S.M. '49, is retired from the Army Corps of Engineers after 30 years, and is now Construction Manager with the Potomac Electric Power Company.

II

Mechanical Engineering

With the Alumni

With the resignation of the administrator of the National Aeronautics and Space Administration came rumors about his replacement, and among the possible candidates is **Rocco Petrone,** '52, a former associate administrator of N.A.S.A. now in private business. . . **Jon Andresen,** S.M. '73, writes that he is research engineer for Southern Pacific Transportation in San Francisco, "responsible for assembling and programming a rail car mounted mini-computer system for data acquisition and analysis of field tests." . . . **Satish Suryawanshi,** '72, is secretary of the M.I.T. Alumni Luncheon Club in Washington. . . **Avi Swartzon,** '75, is Senior Engineer at Eastern Air Lines, constructing a mathematical model of the Environmental Control System of the Boeing 727. In order to improve air passengers' comfort, he is "writing a program of instantaneous computer diagnosis of the working order and efficiencies of all the ECS components. The program is designed to require simple test equipment, simple test procedure, be available for use anywhere in the EAL system, and have no adverse effect on operational scheduling." . . . Among recent appointments in M.I.T.'s School of Engineering are: **Nak-Ho-Sung,** Sc.D. '72, changing from research associate and lecturer to assistant professor of mechanical engineering; **Adam C. Bell,** Sc.D. '69, changing from visiting professor to associate professor of mechanical engineering; **Clark Graham,** Ph.D. '69, changing from associate professor to adjunct professor in the Department of Ocean Engineering. . . **Leonard Kranser,** S.M. '54, is President and Chairman of the Board of Miller Dial Corporation, one of the country's largest manufacturers of industrial name plates, panels, and dials.

III

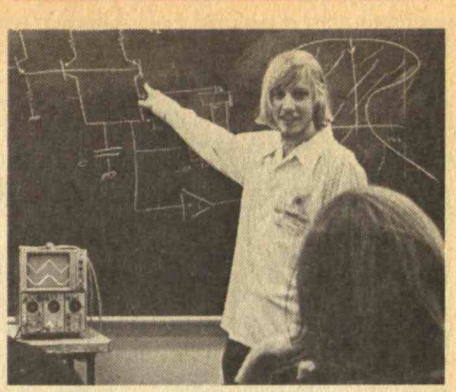
Materials Science

With the Alumni

William J. Harris, Jr., Sc.D. '48, vice president of the Association of American Railroads' Research and Test Department, has become the first railroad industry executive and professional engineer to be elected to membership in the National Academy of Engineering. He was elected on the basis of "research and development, technical planning and system analyses for the railroad industry and contributions to the materials field." . . . **George Economos,** Sc.D. '51, has accepted a position as senior staff officer for the National Academy of Science in Washington, D.C. . . . *Mathematical Modeling of the Chemical, Mechanical, and Physical Properties of Engineering Alloys,* by **John Zotos,** '56, has recently been published by Lexington Books. The book represents a compilation of Professor Zotos' applied research and development findings for the past 20 years of professional activity.

Rodney E. Hanneman, Ph.D. '61, has been named manager of the newly created Materials Characterization Laboratory at the General Electric Research and Development Center, Schenectady, N.Y. . . . **John F. Elliott,** Sc.D. '49, is Chairman of the Program Committee for the Third International Iron and Steel Congress, to be presented at Chicago's Palmer House Hotel, April 16-20, 1978. Dr. Elliott reports that the program will address the relationship of the steel industry to world trade, government relationships to the steel industries of the world, availability of raw materials, and procurement of capital. . . At the Corning Glass Works, in Corning, N.Y., **Gerald S. Melling,** Sc.D. '59, has been appointed manager, optical product development, product development, Technical Staffs Division.

By next fall there will be 25 per cent fewer teaching assistants in the Department of Electrical Engineering and Computer Science, and some tutorials, especially in advanced subjects, will be cancelled. In a tutorial, two or three undergraduates meet with a graduate student (teaching assistant) to discuss course material; some faculty think tutorials are a "luxury," while others say they make the difference between M.I.T. and other electrical engineering schools throughout the country. (Photos: Steven T. Kirsch, '78, from The Tech)



Cutting the Budget for Teaching Assistants

To make its constant budget cover its growing enrollment, the Department of Electrical Engineering and Computer Science will reduce the number of its teaching assistants by 25 per cent next fall, and the result will be a "substantial" change in the "character of instruction in the Department," says Steven T. Kirsch, '78, writing in *The Tech*.

For four years the Department has "dipped into its reserves," according to Professor Frederick C. Hennie III, '55, Executive Officer of the Department, in order to maintain what Mr. Kirsch calls its program of "highly individualized instruction known as a tutorial" in which two or three undergraduates meet weekly with a graduate student tutor to discuss course material. Now the reserves are running out, and the Department will cut its force of teaching assistants from 106 to around 50 in the next two years. Teaching assistants will continue to work in laboratory subjects and in core courses which attract students from many different backgrounds; most of the cuts will affect advanced students.

Mr. Kirsch admits that, according to a recent informal survey of faculty and teaching assistants, attendance at tutorials is only 60 to 80 per cent. Some faculty members he talked to said tutorials are a "luxury . . . a nice thing to have pedagogically." But others took a different view: "Tutorials are what separate M.I.T. from the rest of the electrical engineering schools in the country," thinks Professor James R. Melcher, Ph.D. '62. And Professor Hermann A. Haus, Sc.D. '54, is convinced that "we won't be able to teach as much as we do now."

IV
Architecture

With the Alumni

Alan L. Fishman, M.Arch. '62, joins the firm of Geddes Brecher Qualls Cunningham, in Baltimore, Md., as a Principal Architect. . . **Carl R. Nelson, Jr.,** M.Arch. '56, resigned last year as head of the Department of Environmental Studies at the University of Manitoba, to return to teaching and research. This September, he will join the Department of Landscape Architecture at the University of Manitoba.

V
Chemistry

"Padma Shri," the distinguished Indian title comparable to knighthood of the British Empire, has been awarded to **Ramamoorthy Belagaje,** a research associate in the Department and a member of the research team headed by Nobel laureate Har Gobind Korana which completed the synthesis of the first functional man-made gene.

With the Alumni

The speaker at the meeting of the Northeastern Section of the American Chemical Society in May was **Ronald A. Hites,** Ph.D. '68. His subject: "Toxic Chemicals in the Environment." . . . **Thomas J. Lynch,** Ph.D. '67, is a recipient of a Ph.D. Fellowship of the M.I.T. Health Sciences Fund. His research in the Department of Electrical Engineering will be on measurements of acoustic input impedance of the cochlea in cats. . . . **L. M. Baker,** Ph.D. '60, has been appointed vice president of research and development for the Chemicals and Plastics Operations Division of Union Carbide Corp. Dr. Baker and his wife, Ruth, have three sons and reside in Westfield, N.J. . . . **Manson Benedict,** Ph.D. '35, Professor of Nuclear Engineering at M.I.T., will be a member of the steering committee of the Energy Research and Development Administration which will review the U.S. plan for fast breeder reactor development. . . . **Robert B. Davis,** Ph.D. '66, has been promoted to an associate director of FRL, an Albany International Co., located in Dedham, Mass. Dr. Davis is a specialist in polymer chemistry and will be responsible for research in reverse osmosis membrane development. He and his wife, Frances, and their four children reside in Framingham, Mass. . . . **V. Zale,** S.M. '57, is now research manager of the Filtration and Industrial Minerals Section at Johns Manville Research and Development Center. . . . **Carl A. Renner,** Ph.D. '74, is a research chemist at the Central Research Department of DuPont Co., Wilmington, Del. . . . **Barbara Jetter Schowen,** Ph.D. '64, and her husband, **Dick Schowen,** Ph.D. '63, were at the University of Indiana, Bloomington, last fall. She was researching in the field of lipoprotein chemistry and teaching an undergraduate biochemistry course; Dick taught a graduate seminar on catalysis in chemistry and enzymology.

VI
Electrical Engineering

"For contributions to the theory and applications of optimal control and estimation," Professor **Michael Athans** has been elected a Fellow of the American Association for the Advancement of Science. Professor Athans is also Director of the Electronic Systems Laboratory at M.I.T.

With the Alumni

R. Angell, S.M. '57, retired from the Coast Guard in September, 1975. He is now employed as an engineer in the design of sonar simulators for Tracor, Inc. . . . **Klaus B. Bartels,** M.S. '75, is a communications-electronics engineer with the United States Air Force at their Strategic Communications Area, Offutt A.F.B., Nebraska. He was recently selected for promotion to Captain, and his wife, Leannah, gave birth to a girl in February . . . **Edward E. David,** Sc.D. '50, is off on his own. He announces the opening of the consulting firm, Edward E. David, Inc., in Chicago, Ill. . . . **Scott L. Sears,** S.M. '71, is a naval nuclear engineer and navigator on Fast Attack (SSN) Submarine . . . **Chander Ramchandani,** S.M. '73, is still with Xerox and also a scientist and project manager at the Joseph C. Wilson Center for Technology in Webster, N.Y. . . . **Roy K. Breon,** S.M. '61, moved to Ft. Walton Beach, Fla., in 1973 to be manager of engineering for PRD Electronics Division of Harris Corp. In 1975 he switched to marketing and is currently manager of marketing with PRD. He is married and has a daughter, 15, and a son, 12, and enjoys the Florida life with a house on the bay and a 34-foot cruiser. . . . **Thomas G. Kincaid,** Ph.D. '65, has been appointed manager of the Non-Destructive Testing Program at the General Electric Research and Development Center . . . **Charles A. Desoer,** Sc.D. '53, of the University of California at Berkeley, has been elected a member of the National Academy of Engineering for his contributions to control and system theory, and for innovation in engineering education . . . **Clinton S. Hartmann,** S.M. '69, a member of the technical staff of Texas Instruments Inc., Dallas, has been named the outstanding young electrical engineer in the United States for 1976 by Eta Kappa Nu, a professional engineering fraternity. Mr. Hartmann is manager of the surface acoustic wave technology branch of the advanced technology laboratory at Texas Instruments, and since he joined the company right after graduation he has obtained five patents.

Looking for the "J" particle was like looking for a single particular raindrop in a downpour on a typical city during its rainy season, said Professor Samuel C. C. Ting at a symposium in his honor early this spring. Dr. Ting was co-recipient of the 1976 Nobel Prize in Physics for achieving that goal, and this spring he became the first occupant of a new Thomas Dudley Cabot Institute Chair — "a stunning discovery . . . of the first of a whole new class of subnuclear particles," said President Jerome B. Wiesner, ". . . an important advance in efforts to understand the fundamental structure of the nucleus." (Photo: Calvin Campbell)

The New Cabot Chair to Nobelist Ting

A $1 million gift from the family of Thomas D. Cabot and the trustees of the Cabot Charitable Trust has established the Thomas Dudley Cabot Professorship at M.I.T., and it's now occupied by Samuel C. C. Ting, who shared the 1976 Nobel Prize in Physics for his discovery of the "J" particle.

The Cabots intend that their new Institute Chair honor "exceptional scholarship" in any of the Institute's schools or departments; it is the 18th such endowed professorship to be established under the M.I.T. Leadership Campaign, whose goal is the funding of 50 such endowed chairs by 1980.

Both Louis W. Cabot, Chairman of the Board of Cabot Corp., and his father Thomas D. Cabot, Honorary Chairman, are members of the M.I.T. Corporation, and the Cabot Corp. is a long-time member of the M.I.T. Industrial Liaison Program. The late Godfrey L. Cabot, who founded the firm, was a member of M.I.T.'s Class of 1881, and his father, Samuel Cabot, was among the Boston industrialists whose efforts led to the founding of M.I.T. in 1865.

VIII
Physics

Jens Als-Nielsen, a leading European solid-state physicist who heads the Solid-State Division of the Danish Research Establishment, is Visiting Professor this year. He's considered the leading European experimentalist in neutron scattering, and his work at M.I.T. continues in this field.

With the Alumni

Paul L. Kelley, Ph.D. '62, Associate Group Leader at M.I.T.'s Lincoln Laboratory, is program co-chairman of the 1977 Conference on Laser Engineering and Applications held this June, sponsored by the Institute of Electrical and Electronic Engineers and the Optical Society of America. . . . **George E. Duvall,** Ph.D. '48, Professor of Physics at Washington State University, was the speaker for the 40th Invited Address at W.S.U. in March. He is an authority on theoretical physics and shock wave theory. . . . **Robert D. Maurer,** Ph.D. '51, has been appointed manager of special products and optical wave guide technology in the Technical Staffs Division of Corning Glass Works. . . . **Harry Schecter,** Ph.D. '39, has retired from the department staff of MITRE Corp., but he's still working full-time — in the Joint Tactical Information Distribution Program Office of the Electronics System Division of MITRE . . . A 1977 Fellowship of the Guggenheim Foundation has been awarded to **J. Bruce French,** Ph.D. '48, Andrew Carnegie Professor of Physics at the University of Rochester for theoretical studies in nuclear physics.

Two alumni honored by election to the National Academy of Engineering are: **Robert H. Wertheim,** S.M. '54, of the U.S. Department of the Navy, for his contributions to national strategic programs, and particularly engineering leadership of naval ballistic systems; and **Norman C. Rasmussen,** Ph.D. '56, of M.I.T., for contributions to applied radiation detection, the development of quantitative methods of risk assessment, and nuclear safety. . . . **Robert N. Noyce,** Ph.D. '53, Chairman of Intel Corp., was a speaker at the Conference on Distributed Data Processing, sponsored by International Data Corp., in April.

X
Chemical Engineering

With the Alumni

Samuel W. Bodman, S.M. '65, has been elected President of Fidelity Management and Research Company, Boston . . . **Bob Wohler,** '50, has been appointed Department Manager of Central Chemical Engineering at Polaroid. . . The Power Systems Group of Combustion Engineering, Inc., in conjunction with Statsforetag, A.B. and Uddcomb Sweden A.B., announces the appointment of **George W. Bond,** S.M. '57, as managing director of Uddcomb, a leading European manufacturer of heavy nuclear components. . .**Peter V. Danckwerts,** S.M. '48, is retiring from his position as Shell Professor of Chemical Engineering at the University of Cambridge in September; he will become Emeritus Professor and expects to continue his scientific work at the University. . . . **Sheldon K. Friedlander,** S.M. '50, Professor of Chemical Engineering and Environmental Health Engineering at the California Institute of Technology, is the author of *Smoke, Dust, and Haze: Fundamentals of Aerosol Behavior,* recently published by John Wiley & Sons. . . . Halcon International, Inc., has been reorganized into four profit centers. **Ernest I. Korchak,** Sc.D. '64, is president of Halcon Research and Development Corp.; and **Theodore Stein,** '51, is president of Halcon Computer Technologies, Inc. . . . **George Roberts,** Sc.D. '65, is director of Corporate Research for Air Products and Chemicals, Inc., of Allentown, Penn. . . . A third edition of the *Properties of Gases and Liquids* authored by **Robert C. Reid,** Sc.D. '54, Professor of Chemical Engineering at M.I.T., the late **Thomas K. Sherwood,** '24, former Dean of the M.I.T. School of Engineering, and John M. Prausnitz, was issued in January. It has been completely rewritten and reorganized to present the most current estimation techniques.

XI
Urban Studies

With the Alumni

Donna Davis Berman, M.C.P. '72, has been appointed Noise Management Officer for Logan International Airport, Boston, and Hanscom Field, Bedford, by the Massachusetts Port Authority . . . **Richard S. Howe,** S.M. '61, has been Professor and Director of the Division of Environmental Studies at the University of Texas at San Antonio since July, 1976. . . . **Paul Osterman,** Ph.D. '76, Assistant Professor of Economics at Boston University, gave a day-long briefing at the Worcester Chamber of Commerce in February on the subject, "Methods Developed for Local Labor Market and Educational Planning." . . . Two elected to membership in the National Academy of Engineering are: **Ross E. McKinney,** Sc.D. '51, of the University of Kansas at Lawrence, for contributions to the development of biological waste-water treatment processes and to the advancement of the environmental engineering profession; and to **Perry L. McCarty,** Sc.D. '59, of Stanford University, for contributions to the environmental engineering profession through education, research, and service to government and industry.

XIII
Ocean Engineering

With the Alumni

William E. Heronemus, S.M. '48, Professor of Engineering at the University of Massachusetts, lectured at Smith College, on the U.S. energy problem. Professor Heronemus is an authority on wind-power systems and other non-polluting energy sources. . . . Rear Admiral **Malcolm E. Clark,** N.E. '54, has been named Superintendent of the U.S. Coast Guard Academy, New London, Conn. . . . Captain **Benedict L. Stabile,** N.E. '56, Commanding Officer of the Coast Guard Yard, Baltimore, Md., has been promoted to Rear Admiral. . . . **Robert J. Bosnak,** N.E. '60, has been appointed Chief of the Mechanical Engineering Branch in the Division of Systems Safety at the U.S. Regulatory Commission. . . . **Donn F. Pennell,** '49, was recently named President of the McNair Realty Co., Lewistown, Mont.

XIV
Economics

Four new appointments of Assistant Professors, effective July 1 in the Department of Economics: **Henry S. Farber,** who will complete his Ph.D. at Princeton this month with a thesis on the impact of the United Mine Workers on the coal industry; his primary field is labor economics and industrial relations. . . . **Harry C. Katz,** a specialist in public finance and econmtrics; he's completing his doctorate at the University of California in Berkeley with a thesis on the impact of public employee unions on city budgeting. . . . **Kevin W. S. Roberts,** Research Fellow at St. John's College, Oxford, where he's completing a doctoral thesis on welfare theory and distribution. . . . **Marilyn J. Simon,** a specialist in mathematical economics and health economics; her undergraduate degree is in mathematics (Barnard College), and her doctoral thesis (Princeton) is being completed on medical malpractice insurance systems.

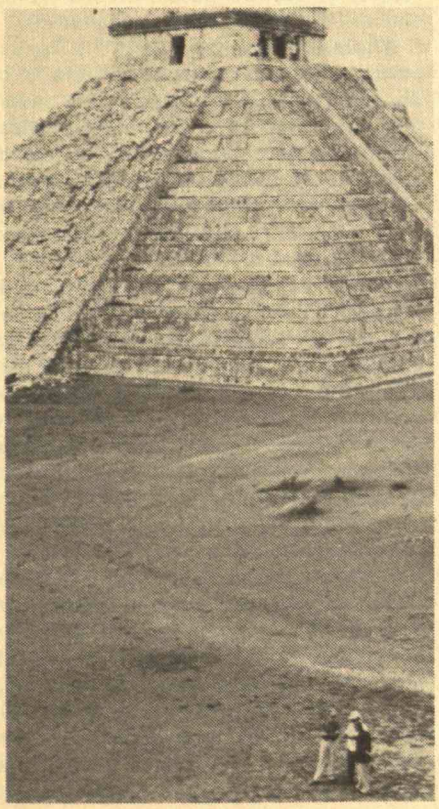
The picture above records one of the moving moments of the M.I.T. Fiesta in Mexico: Clarence M. Cornish, '24, acknowledges a tribute from the Board of Directors of the Alumni Association on his and Luisa's 50th wedding anniversary "for their sustained warmth and friendship toward M.I.T. and its alumni." In the foreground are Dr. Gray (left) and Sr. Sada. (Photos: Ronald S. Stone, '59)

A Tribute to "Nish" Cornish as the Fiesta Moves to Merida

For 29 years the annual Fiesta of the M.I.T. Club of Mexico City has provided a unique combination of fellowship and cultural exploration for countless hundreds of stateside alumni, and for most of those years Clarence M. ("Nish") Cornish, '24, and his wife Luisa have personified the Mexicans' hospitality to their visitors.

In 1977 it was a little different: the Fiesta was in Merida, in the heart of the Yucatan; the guests were as much the members of the Club as their visitors from the north; and Mr. and Mrs. Cornish were more honored guests than hosts.

There were tours of Merida and of the remarkable Mayan cities in Uxmal and Chichen-Itza (below); an address by Andres Marcelo Sada, '52, President of the Confederacion Patronal Mexicana; responses from Edward O. Vetter, '42, President of the Alumni Association, and Paul E. Gray, '54, Chancellor of the Institute; and a special salute for Mr. and Mrs. Cornish.



Mr. Sada's theme was Mexico's "new attitude, new understanding, new focus on our old and new problems . . . based on austerity, productivity, and social solidarity. . . . Today Mexican enterprise has a more participative and militant nature," he said; "it is more scientific and at the same time more conscious of the social role it plays. And it is more committed to the search for solutions to the great problems affecting the country.

"Mexico is not on its knees," he declared. "Mexico is on its way to a healthy recovery, producing and working with freedom intact."

Associate Professorships to 33

Thirty-three members of the faculty have been promoted to the rank of Associate Professor; they're listed below, with their fields of specialization indicated:

Department of Aeronautics and Astronautics: **Charles M. Oman,** Ph.D. '72 — human sensory and vestibular organs; motion sickness. **Nawal K. Taneja,** S.M. '67 —transportation demand; commercial air transportation policy and planning.

Department of Architecture: **Whitney Chadwick** — history of art; 20th century painting and sculpture. **Dolores Hayden** —American environmental history; feminism and design. **Robert J. Slattery,** M.Arch. '70 — architectural design.

Department of Biology: **Paul D. Gottlieb** —immunology and leukemogenesis. **Nancy H. Hopkins** — cancer research. **Bonnie M. Tyler,** Ph.D. '68 — microbial physiology and biochemistry.

Department of Chemical Engineering: **Lloyd A. Clomburg,** Sc.D. '71 — mathematical and experimental modeling of engineering components and systems. **Robert E. Cohen** — physics and chemistry of polymers.

Department of Civil Engineering: **Mohsen M. Baligh** — foundation engineering, slope stability, and soil consolidation. **Moshe Ben-Akiva,** Ph.D. '73 — transportation systems.

Department of Earth and Planetary Science: **Sean C. Solomon,** Ph.D. '71 — history, structure, and dynamics of the crust and upper mantle of the earth and terrestrial planets.

Department of Economics: **William C. Wheaton** — economic institutions and the economics of urban systems and their growth.

Department of Electrical Engineering and Computer Science: **Ira P. Goldstein,** Ph.D. '73 — artificial intelligence and cognitive science. **Alan J. Grodzinsky,** '71 — electrical properties of biological tissue. **Michael Hammer,** '68 — data base management systems and programming languages. **James L. Kirtley, Jr.,** '68 — superconducting electric machines. **Ronald L. Rivest** —computational complexity and optimal algorithms. **Nils R. Sandell, Jr.,** Ph.D. '74 — computer systems and control and estimation theory. **Gerald J. Sussman,** '68 —design, analysis, and explanation of complex systems.

E. R. Cosman

Department of Humanities: **Elzbieta Chodakowska** — English and German philosophy, and American literature. **Patricia Cumming** — writing and editing.
Department of Linguistics and Philosophy: **Ned J. Block,** '64 — intelligence and heritability.
Sloan School of Management: **Gary L. Lilien** — product advertising and marketing.
Department of Nutrition and Food Science: **John D. Fernstrom,** '69 — endocrinology and neurochemistry. **William G. Thilly,** '67 — mutation in human cells.
Department of Physics: **Kenneth Brecher,** '64 — high-energy astrophysics, general relativity, and cosmology. **Marc A. Kastner** — physics of solids. **Ernest J. Moniz** — high-energy electromagnetic interactions.
Department of Psychology: **Susan Carey** — experimental psychology.
Department of Urban Studies and Planning: **Thomas R. Willemain,** Ph.D. '72 — quantitative methods in health planning.

Honors to Students

Eloranta Fellowships to support summer research activities to **Siong H. Chua,** '78 —flood forecasting models for the Pahang basin; **Stewart Davis,** '77 — reaction time to audible signals as conditioned by prior context; **Ilan Peer,** '78 — design and construction of an *in situ* analyzer to measure trace metals in sea water; and **David A. Relman,** '77 — regulation of the intermediary metabolism of the rat kidney.

Among 89 graduate students throughout the U.S. who will hold National Science Foundation postdoctoral fellowships starting next fall: **William F. Ganong III,** psychology; **Robert W. Levis, Jr.,** biology and **Harry M. Meade,** biology. (In addition, eight fellows now working elsewhere have indicated that they will come to M.I.T. for their postdoctoral work next fall.)

To **Richard D. Thomas,** '80, the Young American Award of the Boy Scouts of America for outstanding academic achievement and involvement in community affairs.

. . . **Christopher H. Stetser,** '79, to New England Associate Councillor of the National Society of Physics Students.

Promotions: 15 New Professors

Fifteen of M.I.T.'s present and future leaders were identified this spring by promotion to the rank of full Professor. They are:

☐ **Eric R. Cosman,** '63, in the Department of Physics. Professor Cosman is a nuclear physicist trained in mathematics and physics (Ph.D. '66) at M.I.T.; in addition to his M.I.T. appointment, he has the rank of Visiting Scientist at Brookhaven National Laboratory and Los Alamos Scientific Laboratory, and he's also affiliated with the Max Planck Institute in Germany.

☐ **Stanley Fischer,** Ph.D. '69, in the Department of Economics. Dr. Fischer came to the U.S. from Zambia to earn his doctorate at M.I.T., and — except for a postdoctoral year at the University of Chicago — he's been here ever since; he holds undergraduate and master's degrees from the London School of Economics. A specialist in monetary theory and economic growth, Dr. Fischer is Associate Editor of *Econometrica* and the *Journal of Monetary Economics.*

☐ **Thomas J. Greytak,** '62, in the Department of Physics. Dr. Greytak is in charge of the third course in the three-course undergraduate sequence in theoretical physics, and he also teaches a graduate subject in condensed-matter physics. He's been a member of the faculty since receiving his Ph.D. in physics — following undergraduate study in electrical engineering — in 1967.

☐ **Roman W. Jackiw,** in the Department of Physics. A theoretical physicist, Dr. Jackiw will use a Guggenheim Fellowship for theoretical and mathematical studies in particle physics in 1977-78. He's a native of Lublinec, Poland; studied at Swarthmore and Cornell (Ph.D. 1966); and was a Junior Fellow in the Society of Fellows at Harvard for three years before joining the M.I.T. faculty in 1969. Professor Jackiw is Associate Editor of *Annals of Physics.*

☐ **Norman Jones,** in the Department of Ocean Engineering. Professor Jones is an Englishman trained at the University of Manchester; he came to the U.S. in 1965 and to M.I.T. three years later, having taught in the meantime at Georgia Institute of Technology and Brown University. Dr. Jones was Secretary of the International Ship Structures Congress from 1973 to

S. Fischer

T. J. Greytak

R. W. Jackiw

N. Jones

J. H. Milgram

J. Moses

1976, and his research interests center in the area of the static and dynamic behavior of plates, shells, beams, and other structures.

☐ **Jerome H. Milgram,** '61, in the Department of Ocean Engineering. Dr. Milgram has followed several careers in which ships and the ocean are common denominators. After completing graduate work at M.I.T. (Ph.D. '65) he pioneered in the computer-aided design of sails as partner in the firm of Milgram and Hopkins; soon after joining the M.I.T. faculty in 1967 he was for two years Research Associate in Biophysics at Harvard Medical School; now he is concentrating his research on ocean wave and transport phenomena, especially on the behavior and control of ocean oil slicks.

☐ **Joel Moses,** Ph.D. '67, in the Department of Electrical Engineering and Computer Science. Professor Moses is Associate Director of the Laboratory for Computer Science (formerly Project MAC), a large-scale computer research program, which he joined in 1965 to work in the field of artificial intelligence; and he's Editor of *Transactions on Mathematical Software,* a publication of the Association for Computing Machinery. A native of Israel, Dr. Moses studied at Columbia before coming to M.I.T. for his doctorate in mathematics.

☐ **Harvey M. Sapolsky,** in the Department of Political Science. Dr. Sapolsky's special interests are science and public policy and — more recently — health care policy; he studied at Boston University and Harvard (Ph.D. 1967) and joined the Institute faculty in 1966.

☐ **Robert J. Silbey,** in the Department of Chemistry. Dr. Silbey is a theoretical chemist specializing in studies of interactions and excitations in chemical materials at the molecular level; he's in charge of the Department's graduate subject in advanced solid-state chemistry. Dr. Silbey studied at Brooklyn College and the University of Chicago (Ph.D. 1965) and held a postdoctoral fellowship at the University of Wisconsin before coming to M.I.T. in 1966.

☐ **Anthony J. Sinskey,** Sc.D. '66, in the Department of Nutrition and Food Science. A specialist in the effects of various food processing techniques on microorganisms and on food nutritonal values, Dr. Sinskey holds the 1975 Samuel Cate Prescott Award of the Institute of Food Technologists for distinction as a "young research scientist." He came to M.I.T. from the University of Illinois and joined the Institute faculty after a postdoctoral year at the Harvard School of Public Health in 1967-68.

☐ **Joseph M. Sussman,** Ph.D. '68, in the Department of Civil Engineering. Dr. Sussman is M.I.T.'s "railroad man," a specialist in rail freight service and rail network rationalization. He came to M.I.T. in 1963 following undergraduate study at the City College of New York and graduate work at the University of New Hampshire (M.S. 1963), and he joined the faculty in 1967.

☐ **Glen L. Urban,** Sloan School of Management. Dr. Urban holds a mechanical engineering degree from the University of Wisconsin and advanced degrees in management from Wisconsin and Northwestern University (Ph.D. 1966). His specialty is the design and marketing of new products and services, and he's also worked on the management aspects of family planning.

☐ **David N. Wormley,** '62, in the Department of Mechanical Engineering. Dr. Wormley came to M.I.T. from Moline, Ill., in 1958, and he's been studying and teaching in the field of dynamic analysis and control — including fluid power systems and applications to transportation and fossil-fuel power systems — ever since. His current research deals with the dynamics of guideway systems, rail vehicles, and semi-trailer trucks.

☐ **Mark S. Wrighton,** in the Department of Chemistry. Dr. Wrighton came to M.I.T. in 1972 after receiving his Ph.D. (and the first Herbert Newby McCoy Award) at California Institute of Technology. His research is in photochemistry and metal catalysis — subjects which he teaches at M.I.T. and in which he has lectured throughout the U.S. and in Europe.

☐ **Vernon R. Young,** in the Department of Nutrition and Food Science. Dr. Young's work in nutritional biochemistry is concentrated on human nutrient requirements and protein and amino acid metabolism; he studied animal nutrition at the Universities of Reading and Cambridge, England, and his doctorate (1965) is from the University of California at Davis in the field of nutrition.

H. M. Sapolsky

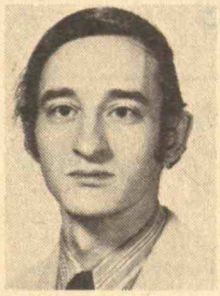
R. J. Silbey

A. J. Sinskey

J. M. Sussman

G. L. Urban

D. N. Wormley



M. S. Wrighton

V. R. Young

Individuals Noteworthy

Kudos: Honors, Awards, Citations

To **F. Stanley Nolan,** '39, director of maintenance analysis at United Airlines' Maintenance Operations Center, San Francisco International Airport, the A.I.A.A.'s Systems Effectiveness and Safety Award for "outstanding contributions to the field of systems effectiveness and safety" . . . to **Rene H. Miller,** Head of the Department of Aeronautics and Astronautics, M.I.T., the I. B. Laskowitz Award for Research in Aerospace Engineering Sciences, Support Systems, and Components — a Gold Medal and a Certificate of Citation.

To **Edward G. Sherburne, Jr.,** '41, a special citation as Publisher of *Science News:* the growth in quality and circulation of this weekly represents "a major publishing achievement . . . a really extraordinary performance;" said William D. Carey, Executive Officer of the American Association for the Advancement of Science Writers in Denver late this winter. . . . To **Robert C. Cowen,** '49, Science Editor of the *Christian Science Monitor,* and **John I. Mattill,** Editor of *Technology Review,* life memberships in the National Association of Science Writers.

Moving to Washington

Two more members of the M.I.T. community have taken top places in President Jimmy Carter's new administration:

John C. Stetson, '43, President of A.B. Dick Co., is Secretary of the Air Force; he was formerly a partner in Booz, Allen and Hamilton and from 1963 to 1970 an executive of the Houston Post Co.

Jordan J. Baruch, '48, formerly a member of the faculty at Dartmouth's Amos Tuck School of Business Administration, is Assistant Secretary of Commerce for Science and Technology. Dr. Baruch studied electrical engineering at M.I.T., and he thinks his new assignment of "helping government and industry work together for the common good . . . will be one of the most challenging jobs in government."

Honors and Awards to the M.I.T. Community

Elected Fellows of the American Association for the Advancement of Science: **Robert A. Alberty,** Dean of the School of Science; **Michael Athans,** Director of the Electronic Systems Laboratory; **Glenn A. Berchtold,** Professor of Chemistry; and **J. Herbert Hollomon,** '40, Director of the Center for Policy Alternatives.

Fellowships of the John Simon Guggenheim Memorial Foundation for special research activities to **Alan H. Barrett,** Professor of Physics; **Robert G. Gallagher,** Professor of Electrical Engineering; **John Harbison,** Associate Professor of Music; **Sidney M. Hecht,** Associate Professor of Chemistry; **Roman Jackiw,** Associate Professor of Physics; **Harvey F. Lodish,** Professor of Biology; **David M. Perlmutter,** Ph.D. '68, Associate Professor of Linguistics; **John R. Ross,** Ph.D. '67, Professor of Chemistry; and **M. Jonathan Rubin,** Fellow at the Center for Advanced Visual Studies.

The 1976 Applied Mathematics and Numerical Analysis Award of the National Academy of Sciences (including a $5,000 honorarium) to **Chia-Chiao Lin,** Institute Professor and Professor of Applied Mathematics . . . to **Bruce Mazlish,** Head of the Department of Humanities, the Remsen Bird Lectureship at Occidental College, Los Angeles . . . to **Dietmar Seyferth,** Professor of Chemistry, membership in the German Academy of Scientists Leopoldina.

Walter A. Rosenblith, Provost, delivered a major address at the inauguration of June Louin Tapp as Provost of Revelle College, University of California at San Diego . . . **Judith J. Wurtman,** Research Associate, and **Richard J. Wurtman,** Professor of Endocrinology and Metabolism, both in the Department of Nutrition and Food Science, are co-editors of a new Raven Press series on "Nutrition and the Brain."

National Science Foundation National Needs Postdoctoral Fellowships to **William F. Ganong,** Department of Psychology, and **Harry M. Meade,** Department of Biology.

Counselors: Officers, Directors, Advisors

Three elected to the Board of Trustees of the New England Solar Energy Research Institute Corporation: **Robert R. Everett,** S.M. '43, President, The Mitre Corp., Bedford, Mass. . . . **Ivan A. Getting,** '33, President, The Aerospace Corp., El Segundo, Calif. . . . **Breene M. Kerr,** '51, Senior Partner, Resource Analysis and Management Group, Oklahoma City . . . **Ernest C. Brown,** '75, who will be the first graduate of the Berkeley joint program in law and engineering, to the Board of Editors of the Ecology Law Quarterly . . . **Robert C. Casselman,** '39, Associate Director of the Museum of Fine Arts, to the Board of Trustees of the Metropolitan Cultural Alliance . . . **Blev C. Dunklin, Jr.,** '55, Eastern region manager for Demarche Associates, to Vice Chairman of the Special Gifts division of the Darien (Conn.) All Ages Y.M.C.A. Building Fund campaign . . . **Dr. Harry Washington Fritts, Jr.,** '43, professor and researcher, S.U.N.Y. Stony Brook, to the National Heart, Lung, and Blood Advisory Council of the National Heart, Lung, and Blood Institute . . . **Norman B. Leventhal,** '38, President, the Beacon Companies, Boston, to a one-year term as a Director of the United Way of Massachusetts Bay . . . **Robert H. Welsh,** '48, Executive Vice President of Ludlow Corp., to the Board of Directors of that organization . . . **Thomas R. Williams,** S.M. '54, Chief Executive, First National Holding Corp., Atlanta, to Chairman of that organization.

Appointments: Rising in the World of Business

George W. Bond, S.M. '57, Managing Director of Uddcomb, European manufacturer of heavy nuclear components . . . **E. Fred**

Brecher, '53, Principal of Geddes Brecher Qualls Cunningham: Architects, Philadelphia ... **Robert A. Dennis,** S.M. '70, Senior Research Analyst of Scudder, Stevens & Clark, New York ... **Alan L. Fishman,** '62, Principal of Geddes Brecher Qualls Cunningham: Architects, Philadelphia ... **Carlton E. Gebhart,** '59, Division Manager of Joslyn Manufacturing and Supply Company, Hardware Division, Chicago ... **Robert C. Kyser, Jr.,** '57, Principal, Rath & Strong, a Boston-based management consulting firm ... **Edward F. Maguire,** '62, Personnel-Business Manager of Andover, Mass., schools ... **Robert L. Sinsheimer,** '41, Chancellor of the University of California, Santa Cruz campus.

Fellows

Four new Fellows of the Institute of Electrical and Electronic Engineers: **Alexander Kusko,** S.M. '51, President of Alexander Kusko, Inc., Consulting Engineers, Needham Heights, Mass., and Lecturer in Electrical Engineering at M.I.T. ... **James Russell Melcher,** Ph.D. '62, Professor of Electrical Engineering at M.I.T. ... **Alan V. Oppenheim,** '59, Professor of Electrical Engineering at M.I.T. ... and **Gerald L. Wilson,** '61, Professor of Electrical Engineering at M.I.T. **Jordan L. Gruzen,** '57, Chief Executive of Gruzen & Partners, New York, to the College of Fellows of the American Institute of Architects ... **Russell G. Meyerand,** '55, Director of Research, United Technologies research Center, to Fellow of the American Institute of Aeronautics and Astronautics ... **Bruce D. Schobel,** '74, Assistant Actuary, Prudential Insurance Co., Newark, to Fellow of the Society of Actuaries ... **Clinton B. Seeley,** M.D., '51, Andover, Mass., to Fellow of the American College of Radiology.

M.I.T. Administration Changes

Cynthia C. Bloomquist, '70, Industrial Liaison Officer, to Assistant Director of the M.I.T. Associates Program ... **Allan S. Bufferd,** '59, Assistant to the Treasurer, to Assistant Treasurer ... **Walter Lehmann,** S.M. '75, Market Planning Manager for Stewart Warner Corp., to Assistant Director of the M.I.T. Associates Program ... **Kimball Valentine,** formerly Assistant to the Treasurer and Insurance Officer, to Insurance and Legal Administration Officer.

Dugald C. Jackson, Jr., 1896-1977

Dugald C. Jackson, Jr., '21, who was active in M.I.T. alumni affairs throughout his 40-year career in engineering education and administration, died of cancer on March 17 at his retirement home in Havre de Grace, Md. He was 81.

Since receiving his S.M. degree in electrical engineering at M.I.T. in 1922, Mr. Jackson had taught at the University of Missouri, Duke University, the University of Louisville (where he was Head of the Departments of Mechanical and Electrical Engineering from 1925 to 1930), the University of Kansas, the Lewis Institute (of which he was Director from 1935 to 1938), and the University of Notre Dame (where he was Dean of Engineering from 1939 to 1945). Mr. Jackson was Chief of Scientific Training at the Ballistics Research Laboratories, Aberdeen Proving Ground, from 1948 until his retirement in 1963.

Mr. Jackson was the son of the late Dugald C. Jackson, who was Head of the Department of Electrical Engineering at M.I.T. from 1907 to 1935 and founder of the Boston consulting engineering firm of Jackson and Moreland.

Paul J. Cardinal, 1904-1977

Paul J. Cardinal, '24, retired Vice President of Hoffman-La Roche, Inc., who had been a leader in the activities of his Class, died in Naples, Fla., on March 28. He was 73.

Mr. Cardinal was Chairman of the 35th Reunion of the Class of 1924 and went on to become its Senior Vice President, Acting President (1963 to 1964), and President (1964 to 1969); and he arranged its 50th Reunion in 1969 as Reunion Chairman. He was Vice President in charge of Hoffman-La Roche's Bulk-Vitamin Division at the time of his retirement in 1963, and he was a Charter Member of the Pharmaceutical Advertising Club.

Manuel S. Vallarta, 1898-1977

Manuel Sandoval Vallarta, '21, an important member of the Department of Physics at M.I.T. from 1923 until he returned to his native Mexico in 1946, died in Mexico early in April. He was 79.

Dr. Vallarta's undergraduate degree was in mathematics, and he continued for his doctorate (Sc.D. '24) in the Department of Physics, one of the first Mexicans to hold an advanced degree from the Institute. Thereafter, as a member of the faculty, he did pioneering research on cosmic rays and the information they yield on the earth's environment in the solar system, and he also made important contributions to the role of science at the Institute and to the development of science and engineering in Mexico.

In 1943 Professor Vallarta was on leave to serve as Executive Chairman of the Mexican Council for the Promotion and Coordination of Scientific Research; for the next five years he was at the helm of Mexico's National Polytechnic Institute, where he is regarded as one of the founding fathers. In 1952 he was made Under Secretary of Education in Mexico, and at the time of his death he was a founding member of the Commission Nacional de Energia Nuclear of Mexico. His honors included membership in the Papal Academy of Sciences (1961), an Honorary Professorship in the Universidad Mayor de San Andres, Mexico (1958), and El Premio Nacional de Ceincias of Mexico (1959).

Deceased

Arthur L. Collier, '02; April 12, 1977; 7 Hillcrest Rd., Marblehead, Mass.
Myron W. Dole, '04; April 11, 1977; 910 W. Hughey St., Kissimee, Fla.
Clifton N. Draper, '07; December, 1971
Harry L. Sargent, '07; September 21, 1949; East Wolfboro, N.H.
Edward J. Colgan, '09; March 27, 1977; 17 Church St., Ware, Mass.
Edwin W. Goodwin, '11; February 1, 1974; Tie County General Hospital, Kittery, Maine
Martin C. Cherry, '12; January 29, 1976
Gerald B. Howard, '12; December 24, 1974; 6315 Hillsboro Rd., Nashville, Tenn.
Paul E. Rudolph, '13; February 2, 1977; 77 W. Washington St., Chicago, Ill.
Archibald H. Spaulding, '13; March 25, 1977; 703 Main St., Hingham, Mass.
Kirk McFarlin, '14; April 2, 1977; 24 Delwick Ln., Short Hills, N.J.
Edwin R. Hanson, '17; April 24, 1977; P.O. Box 203, Jaffrey Center, N.H.
Sidney Blaisdell, '18; January, 1977; Royal Bonnet Ct., Apt. 401, Shell Pt. Village, Fort Myers, Fla.
Louis J. Brown, '19; August 30, 1976; P.O. Box 377, Rutland, Mass.
Harold J. Murray, '20; March 25, 1977; 4406 Sherwood Rd., Jacksonville, Fla.
Manuel S. Vallarata, '21; April 18, 1977; Fujiyama 745, Mexico 20, DF, Mexico
Francis J. Laverty, '22; August 1, 1976; 4025 Chippewa Dr., Boulder, Colo.
Mrs. Frederick C. Paul, '22; January 20, 1977; East Palatka, Fla.
Carl H. Sebenius, '22; March 29, 1977; 425 E. Green St., Rm. 701, Pasadena, Calif.
Mrs. Roger S. Walke, '22; January, 1977; 25211 Stockport #251, Laguna Beach, Calif.
Herbert C. Button, '23; October 4, 1976; Carriage House East, Apt. 26-C, Mandius, N.Y.
John A. Wineman, '23; September 11, 1975; Rt. 1, 2405 Fallston Rd., Fallston, Md.
Paul J. Cardinal, '24; March 28, 1977; 707 Port Side Dr., Naples, Fla.
John H. Carson, '24; February 2, 1976
C. Sterling Webber, '24; April 4, 1977; 5 Loudon Ln. S., Loudonville, N.Y.
George G. West, '25; July 1, 1976; 3585 Fairview, West Linn, Ore.
Edward S. Campbell, '26; March 24, 1977; 8005 Sand Point Way, NE, Apt. A51, Seattle, Wash.
William K. Cane, '27; September 23, 1976; 1316 Woodwide Pkwy., Silver Spring, Md.
Harry M. Fitts, '27; April 18, 1976; 146 Minot St., Falmouth, Mass.
Joseph S. Farwell, '28; February 4, 1977; 1980 Commonwealth Ave., Apt. #5, Brighton, Mass.
Holmes Iveson, '28; March 31, 1977; 26 Knowles St., Auburn, Mass.
Walter C. Weatherby, '29; October 2, 1950
Robert B. Schildknect, '30; March 24, 1977; 3431 Paxton Ave., Apt. #1, Cincinnati, Ohio
Enar Nilsson, '31; December, 1971
Delano C. Cannon, '32; February 2, 1977
John W. Robins, '33; March 26, 1977; 95 Cedar Ln., Westwood, Mass.
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The Coming Energy Shortage: Oil is Not Enough

Four years ago the "energy crisis" seemed to many no more than an episode in history — the result of a brief, unexpected, and exceptional action by a group of Arabian oil producers in the autumn of 1973. But we are now beginning to understand that the dislocations of 1973 were in fact first signs of very large, long-term problems. Studies by the Workshop on Alternative Energy Strategies (W.A.E.S.), established at M.I.T. two years ago, now make it clear that the world is moving steadily — and probably more rapidly than most of us have realized —towards a new and massive energy crisis, the result of rapid depletion of the fuels on which we have come to rely most heavily.

In particular, rapidly rising oil demand may outstrip supply in the non-Communist world as early as 1985, only eight years from now. Significant amounts of energy from alternative fuels may be needed in less than a decade to meet large and growing energy demand. Because large investments and long lead times are required to produce these fuels on a scale large enough to fill the prospective shortage of oil, the urgent task for the world is to begin now to manage a transition from dependence on oil to greater reliance on other fossil fuels, nuclear energy, and — ultimately — renewable energy systems.

Problems and Alternatives

The Workshop on Alternative Energy Strategies, an experiment in international collaboration led by Professor Carroll L. Wilson of M.I.T., has been carried out over the past two-and-one-half years by senior academic, government, and industrial leaders in the principal western industrial nations and in Japan, Mexico, Iran, and Venezuela, each supported in each country by one or more active associates; and their studies have been coordinated and supplemented by a small central staff at M.I.T.

Participants and associates in each country developed estimates of the demands for energy and the preferred fuels for meeting those needs in their countries in 1985 and 2000, and they drew on their nations' best estimates of fuel reserves to determine domestic energy supplies likely to be available on those dates. Surpluses of fuels were assumed to be available for export. Estimates of energy supplies, demands, exports, and imports in other nations were added on the basis of data from those nations, from special W.A.E.S. studies, and from international sources.

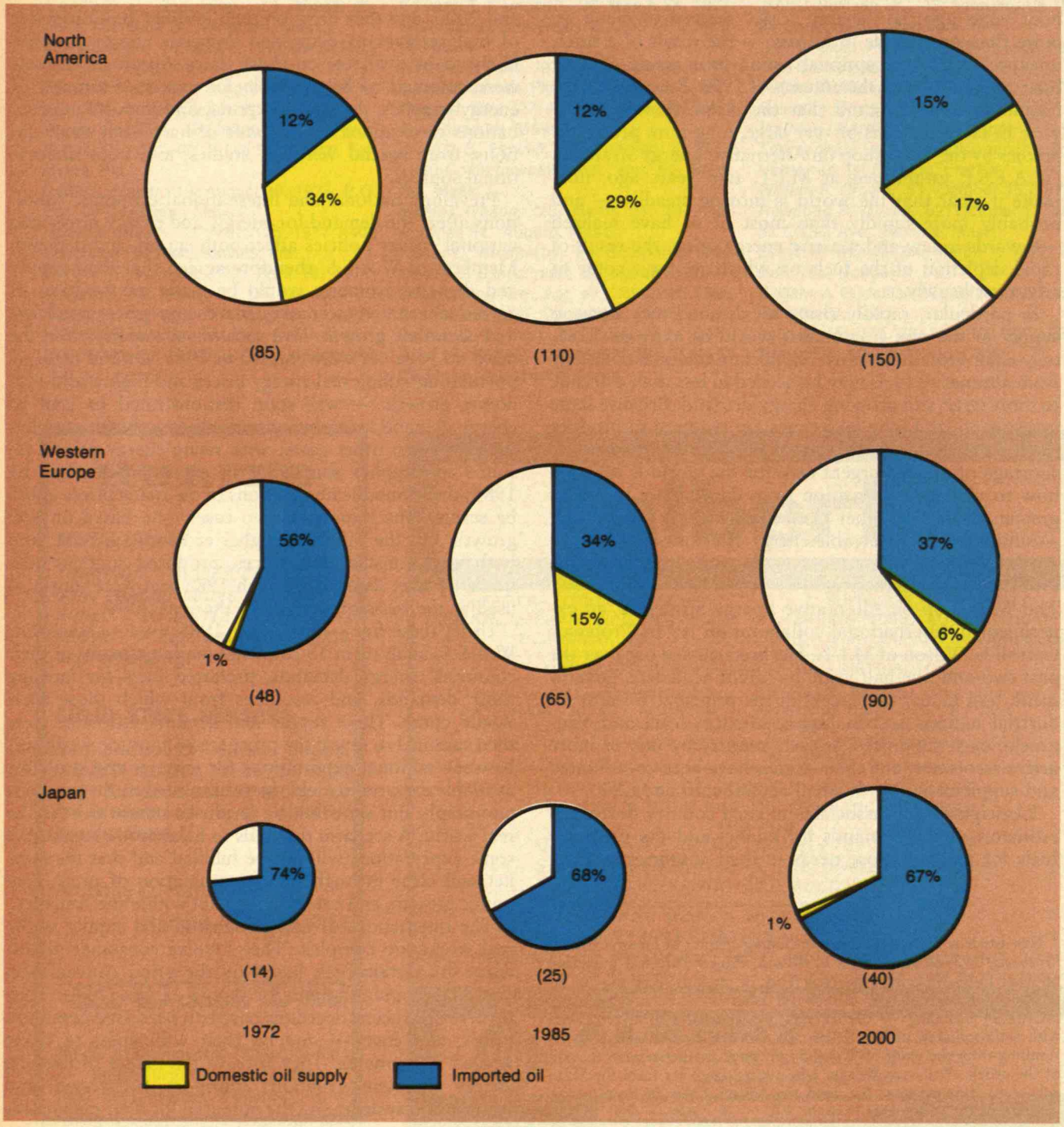
Prevailing national and international economic conditions affect the demand for energy, and energy prices and national energy policies affect both supply and demand. Members of W.A.E.S. therefore agreed that their supply and demand estimates would be made on the basis of agreed alternative scenarios for energy prices, policies, and economic growth. Five such scenarios, shown in the table on page 49, were studied to 1985. One of them — postulating falling real energy prices and high world economic growth — was soon demonstrated to lead to energy demand inconsistent with all conceivable supplies by 1985; two other cases, with rising energy prices, resulted in supplies somewhat in excess of demand by 1985; the economic implications of the rising prices could be severe. The remaining two cases, one based on low growth and the other on higher economic growth, and both with constant fuel prices, produced supplies adequate to meet demand through 1985 and were thus also used as the basis of analysis to the year 2000.

Using these five — and, after 1985, two — scenarios, W.A.E.S. analysts in 13 countries made estimates of their countries' energy demands, preferred fuels for meeting those demands, and resources from which those fuels would come. These supply and demand estimates were then summed to reveal the prospective gaps (or surpluses) between national expectations for imports and probable available exports to yield the results cited in the previous paragraph. But shortfalls or surpluses cannot exist in the real world. A scenario that fails to balance is a signal that some expectations will not be fulfilled and that the market will clear through some combination of price, economic growth, and energy policy not within the scenario.

The interactions of energy demand and supply in the real world are complex. They involve consumer preferences for certain fuels based on the price, convenience, cleanliness, and reliability of supply of those fuels. They involve producers' decisions based on perceived demands, prices, and costs — and on their willingness to make needed investments. They involve the extent of existing energy processing, refining, transport, conversion, and distribution systems and the potential for their expansion.

* This article is drawn from the concluding chapter of *Energy: Global Prospects, 1985-2000*, Carroll L. Wilson, Project Director, published on May 16 by McGraw Hill, New York; it presents the results of intensive studies by the Workshop on Alternative Energy Strategies (W.A.E.S.) including 70 participants and associates in 15 countries with a central staff at M.I.T., described in the article. Other reports resulting from the work of W.A.E.S. are listed as references at the end of the article. Professor Wilson, who retired last year from the Sloan School of Management, has held the Mitsui Chair in Problems in Contemporary Technology.

There is no escaping the central issue of oil in the coming "energy crisis." This chart shows the oil consumption of North America, Western Europe, and Japan as a proportion of total energy use in 1972 and these regions' expected oil consumption in 1985 and 2000 under conditions of high economic growth and high fuel prices (Case C on page 49). The numbers in parentheses show the total energy demand, in millions of barrels per day oil equivalent, in each case; the areas of the circles are in proportion to these totals. North America is the only region that is also a significant producer; but its projected imports are large, and they represent a substantial drain on world oil supplies in 1985 and 2000. In total, the prodigious desired imports of energy in the form of oil shown on this chart will exceed available supplies by soon after 1985, according to W.A.E.S. analyses, necessitating fuel substitutions and major conservation efforts.



Under any reasonable estimates for world economic growth, shortages of petroleum are inevitable before 2000. In the coming critical years we must seek new policies and technologies on which new, large-scale energy options can be based.

And they involve a myriad of national political decisions that may motivate and facilitate — or discourage and impede — a diversification of supply sources, or an emphasis on certain fuels in preference to other fuels.

In W.A.E.S. we have tried to incorporate all these variables in the conceptual models we have used for our analyses of global energy prospects to the year 2000. As a result, our integration process can reveal both problems and policy alternatives:

— It can reveal specific problems in a particular country or region — such as shifts in the mix of fuels needed to reach supply-demand balances.

— It can suggest the cost, infrastructure, and timing of efforts required to balance supply and demand. What does a U.S.A.-Europe coal trade involve?

— It can reveal the most economically efficient (least total cost to world consumers) adjustments, within tight physical and political constraints, for closing supply-demand gaps.

— It permits policy analysis: policies, costs, technical potentials, demand targets, and timings can all be varied.

We used two integration procedures. We first assembled data on "preferred" fuels for fulfilling energy requirements without considering the availability of desired energy imports; this is our global *unconstrained integration.* Then we performed global *constrained integrations,* in which we forced the fuel mix (for the same energy demand) to conform to fuels availability. The first form of integration reveals supply-demand imbalances, while the second shows how the balancing of supply and demand may be achieved.

In the unconstrained integrations, preferred national demands for energy and for each fuel are used to examine how energy moves from raw source to end use and the energy losses at each stage along the way. We also summarize the indigenous supplies for meeting those demands. Supplies and demands rarely balance, and the net difference is the implied requirement for imports or implied availability of exports of each fuel by each country in each scenario case.

These national projections are added together in the global integration process to reveal whether demand and supply are globally in balance. If the answer is yes, fuels can be allocated in world trade so that potential exports balance unfilled demands. If demand and supply do not balance, then the gaps represent differences between national expectations and the realities of globally limited fuel supplies — the scale and timing of global energy and fuel gaps.

In constrained integrations we force shifts in the fuel mix beyond the range of consumer preferences to meet stated energy requirements. These shifts are based on global supplies. Constrained integrations are done to see if it is possible to close prospective supply-demand gaps in a particular scenario — and to determine changes required in the energy system to do so. Such analyses were supported by GEMM, the Global Energy Mini-Model (a highly constrained linear programming model) developed at Atlantic Richfield Co. for the W.A.E.S. project.

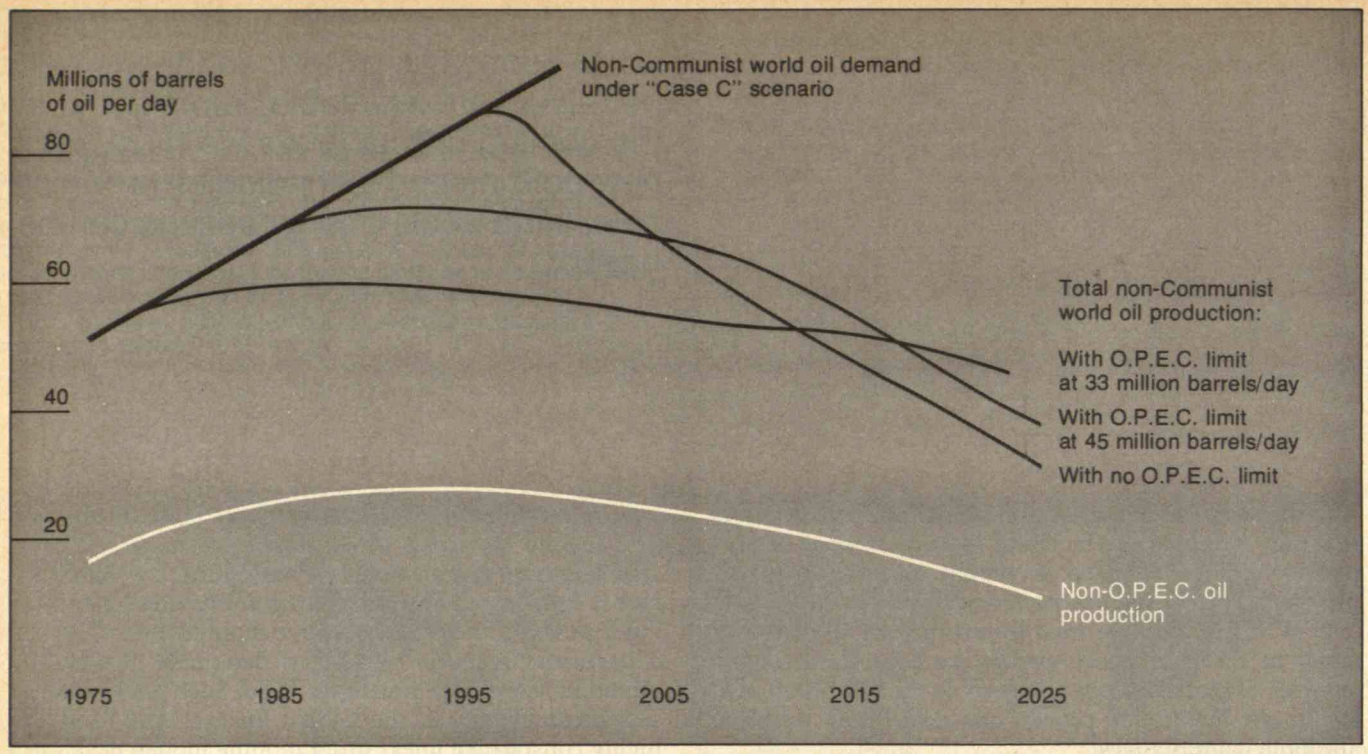
The basic rule for making decisions in these calculations is: meet all end-use energy demand as nearly as possible — that is, make total energy supply and demand balance through that expansion of supply, processing, distribution, and use infrastructure (within any technical or political limits) which results in least total cost to world consumers. To achieve such a balance in stressed scenarios where some (preferred) fuels are in shortage while others (not preferred) are in surplus, substantial fuel switching was found to be necessary. This was done so that each fuel was used with maximum efficiency, minimizing losses in processing and conversion.

Oil Emerges as the Critical Resource

The outstanding result from our analysis of energy supply and demand over the period to the year 2000 is the inevitability of growing future shortages of oil over reasonable ranges of energy prices, policies, and economic growth. Oil demand is projected by our data to increase by about 10 million barrels a day every six years after 1975, reaching 63 million barrels a day by 1985. But oil production in the non-Communist world is unlikely to exceed 70 million barrels a day at any time, and resource and production limitations will begin to restrict oil supply sometime between 1985 and 1990. Further increases in oil demand beyond 1990 simply cannot be satisfied, and those energy requirements must be met with other fuels.

Filling the prospective oil shortfall becomes increasingly difficult as we approach the end of the century. What begins as a minor discrepancy before 1990 widens rapidly in typical cases to a gaping deficit of some 20 million barrels a day by the year 2000. This is equivalent to an oil flow greater than half of O.P.E.C.'s maximum production to date (30.5 million barrels per day in 1973); it is approximately equivalent to the total energy consumption of western Europe and Japan today.

This picture persists under a variety of assumptions; the problem does not go away within the range of any of the W.A.E.S. scenarios about economic growth, energy



Under all W.A.E.S. scenarios studied, oil production in the non-Communist world fails to meet demand sometime between 1985 and 2000. The demand line on this chart is based on Case C assumptions (see table, page 49) — high economic growth rate, rising energy price, vigorous government response, and gross additions to oil reserves of 20 billion barrels per year. The high curve ("No O.P.E.C. production limit") assumes that exporters produce oil as rapidly as technical and physical constraints permit. The lower curves assume that O.P.E.C. production is limited due to political or economic considerations; the lowest illustrates the effect on world oil supply of O.P.E.C. maintaining present ceilings of 33 million barrels/day.

price, and national policy between now and the year 2000. In each of our cases this oil shortfall is nearly 30 per cent of total potential oil production of all the non-Communist nations in the year 2000.

Our projections of energy supplies and demands — and imports and/or exports — for the major consuming and producing regions are summarized in the charts on page 46. These illustrate the relative import-dependence of the consuming regions and the potential exports from producing regions between 1972 and 2000 under conditions of rapid economic growth, vigorous government energy policies — including strong conservation measures — and rising energy prices. They show that total energy demand will exceed supply in the year 2000 by only between 5 and 8 per cent. But they reveal a much more important problem: the very large imbalance between the supply of and demand for oil. No small adjustments will suffice to correct this real imbalance.

Gas and Coal Imports and Exports

The situation with respect to natural gas is not as critical. The W.A.E.S. analysis shows that the reserves of gas in the O.P.E.C. nations are sufficient to meet major importers' desired imports, as well as to provide for increasing domestic requirements. However, 12 to 17 per cent of total gas demand will have to be met by importing; this is far in excess of present gas trade, and ways must be found to move the increased amounts of gas to markets. Alternatively, demands must be reduced through conservation or acceptance of substitute fuels.

Coal is not, we find, a "preferred" fuel, because of problems due to pollution and handling. Yet the maximum potential for coal production exceeds desired coal demands by as much as 30 per cent of total coal demand. Nearly all coal demand estimates are based on estimates of indigenous production from known supplies in each country. Potential global exports are greatly in excess of desired imports. In fact, prospective coal surpluses are about the same size as total desired coal imports under conditions where other fuels are available.

If demands for coal could be increased (as a substitute for oil and gas), these coal surpluses could be used to help close the oil gap. Strategies for the use, transport, and conversion of coal are obviously of critical importance.

Fuel Switching for Energy Balancing

Energy imbalances revealed in our analyses of prospective supply and demand cannot occur in the real world; some demands will have to be reduced or supplies increased. Prices above those we assumed, rationing, still lower economic growth than in our assumptions, etc., all would reduce demand; yet such dislocations and disruptions can be very undesirable "solutions." They may in fact be energy disasters.

The purpose of the W.A.E.S. constrained integrations is to analyze alternatives for resolving these potential imbalances. When desired fuel mixes lead to demand in excess of supply, one useful adjustment is to allocate fuels to uses in such a way that the energy content of each fuel is put to maximum use. For example, the substantial heat loss associated with converting fossil fuel into electricity can be reduced by putting fossil fuels in end-use markets

as fuels — not in electric power plants — while using other options such as nuclear for generating electricity.

Our constrained integrations, which incorporate such steps, do not represent "predictions" of future energy sources and uses. Rather, they represent a description of a situation in which all fuels are used in their most efficient way, within reasonable physical constraints, given the particular W.A.E.S. economic, policy, and price assumptions. They show what might be done with concerted fuel-switching actions, and we believe they show the two major directions in which we must move if we are to match supplies and demands to obtain an energy balance to the end of the century:

— All energy resources and conservation measures must be pursued vigorously to meet total projected demand. Low levels of coal or nuclear development, or less-than-aggressive conservation, would result in the failure of energy supplies to meet projected demand levels at reasonable prices and rates of economic growth.

— Energy supplies in the 1990s will depend on decisions taken in the next few years — a period when we are unlikely to have severe energy imbalances. It is critically important to look beyond the next decade in making today's policy decisions.

Energy Balances and Imbalances in 1985

Within the range of W.A.E.S. assumptions, peaking of world oil production will take place somewhere between 1981 and 2004; this is the critical energy problem for the world —the peak and decline of oil production in the face of rising oil demands. The year 1985 thus becomes of special interest for study.

For 1985, W.A.E.S. energy supply-demand integrations reveal:

— With a constant oil price ($11.50 per barrel in 1975 U.S. dollars) and real economic growth ranging from 3.4 to 5.2 per cent per year worldwide, sufficient supplies of energy are potentially available to meet total demands. In addition, demands for each fuel can be met with projected supplies.

— With an oil price rising to $17.25 per barrel (1975 U.S. dollars) by 1985 and economic growth between 3.4 and 5.2 per cent per year, there appear to be significant potential surpluses of all fuels over consumers' preferences for those fuels. The implication is that the price of $17.25 is probably higher than needed to bring on sufficient supplies and — therefore — that energy prices are not likely to reach that figure by 1985.

— With a falling oil price (to $7.66 per barrel in 1975 U.S. dollars) and high economic growth (5.2 per cent per year worldwide), there are insufficient quantities of certain fuels available to meet consumers' preferences for those fuels in 1985. In addition, total available energy falls short of total demand. The case indicates that an oil price of $7.66, coupled with high economic growth, will not generate sufficient supplies to support the high demands resulting at that price.

While all cases but the falling-price scenario "balance" in 1985, it should be remembered that the estimates assume maximum potential supplies consistent with our assumptions. Given lead times of five to ten years or more for many projects, failure within the next year to make commitments, to resolve the many current constraints on production, and to develop future supplies may foreclose some options for 1985.

Energy Balances and Imbalances in 2000

In nearly all of our cases for the year 2000, the total of energy demands exceeds expected supplies. Even with the most efficient mix of fuels this is so; with "preferred" mixes, the discrepancy is larger.

Even more important than the overall discrepancy are the prospective shortages of specific fuels. The most important of these are significant oil gaps — prospective shortfalls between potential (maximum) oil supply and preferred oil demand based on our assumptions. For example, with rising energy price (to $17.25 by 2000) and high economic growth (4.0 per cent per year) from 1985 to 2000, potential oil available in the world in the year 2000 falls short of the desired oil demand by some 20 million barrels a day. With constant energy price ($11.50) and low economic growth (2.8 per cent per year) to 2000, the oil shortfall is some 15 million barrels per day. These prospective shortages represent, in each case, about 30 per cent of the total desired oil imports of the non-Communist nations. In other words, given the assumptions of these W.A.E.S. cases, only about two-thirds of the aggregate desired global oil imports could be met by available oil exports from producers in the year 2000.

On the basis of these and other cases studied, we therefore conclude that world oil demand will probably overtake supplies sometime between 1981 and 2004 under any set of plausible assumptions.

Natural gas supply and demand balance closely in the year 2000, but global totals obscure the real point about natural gas. The gas supply-demand mismatch in the year 2000 is localized; the supply is not in the same geographical regions as the demand. For all our cases, some 3 to 4 million barrels per day (oil equivalent) of expanded trade — trade in excess of present operational and planned projects — would be needed in 2000 to meet desired gas demands. If gas demands are unmet it will be because of infrastructure limitations — inadequate pipeline and LNG tanker capacity — rather than resource limitations.

The coal outlook is quite different. Coal is not a preferred fuel. It produces substantial pollutants when burned (which can be avoided only at considerable expense), creates ashes to be disposed of, and is not easily handled for transport; furthermore, many changes in existing user devices would be required for its widespread adoption. Yet world reserves of coal are enormous and largely untapped.

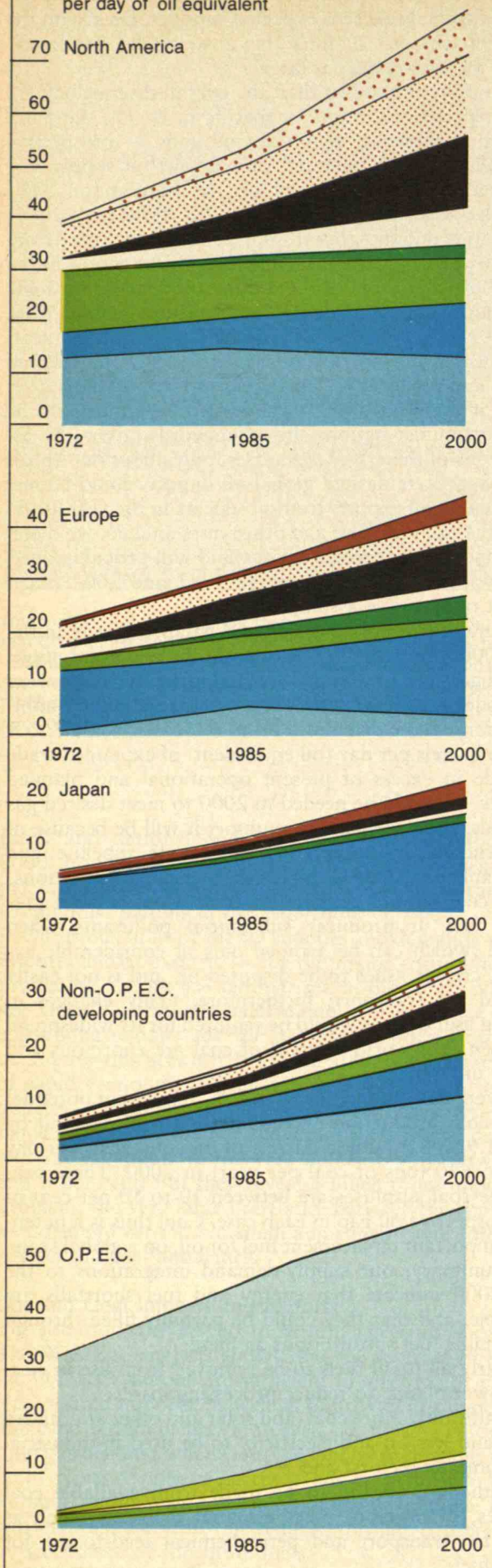
In every case studied by W.A.E.S., maximum potential world coal production exceeds desired coal demand by some 1.9 to 8.2 million barrels of oil equivalent per day (140 to 620 tons of coal per year) in 2000. These prospective coal surpluses are between 10 to 50 per cent of the prospective oil gap in each case. Coal thus is a potentially important replacement fuel for oil, on a global scale.

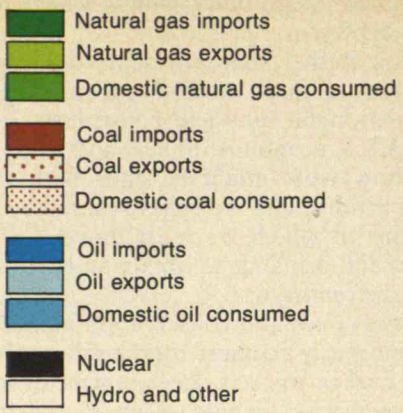
In summary, our supply-demand integrations to the year 2000 indicate that energy and fuel shortfalls are probable, and that they could be partially filled through such major fuel substitutions as these:

— Nearly all fossil fuels to be removed from use in electric power plants, to reduce processing losses;

— Significantly more coal (and solar and other alternative fuels) and less oil and electricity to be used in industrial and domestic sectors; and

— Synthetic crude oil to be made from available coal supplies, in order to meet essential demands (such as those for transport and petrochemical feedstocks) for liquid fuel.

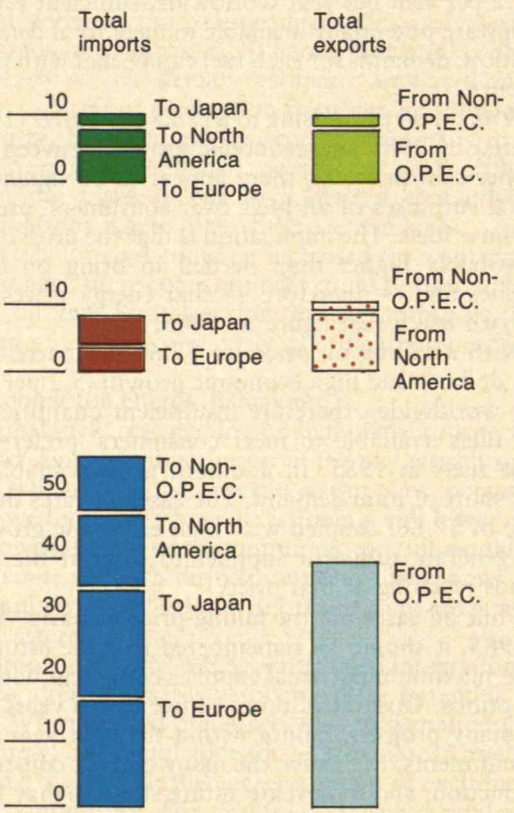




W.A.E.S. projections of regional energy supply and demand between 1972 and 2000 — assuming imports of desired fuels would be available — are summarized on this page. These figures are those for the case of rapid world economic growth (4.4 per cent a year from 1972 to 2000) and rising energy prices (to $17.25 per barrel of oil equivalent in 1975 dollars by the year 2000).

The bars below show the totals of desired imports and available exports of each fuel. There is a substantial shortfall of oil, the preferred fuel, and a modest surplus of coal. And overall there is an energy shortfall — a total world demand for energy larger than fuel supplies can meet.

Having determined the sizes and timing of these shortfalls, W.A.E.S. analysts turned to devising broad strategies — including fuel substitutions — by which supply and demand could be made more nearly equal.



A Case Example: Energy in 2000 After 25 Years of Economic Growth and Price Increases

The global energy futures envisioned by W.A.E.S. can be best illustrated by an example. For this purpose we choose a case based on rapid economic growth (4.4 per cent per year average from 1972 to 2000) and rising oil price ($17.25 per barrel by 2000). This is not necessarily the most likely or the most typical of our cases for the year 2000. The analysis simply illustrates the directions and potentials, within the limits of the scenario, the problems with which we are confronted, and the actions and programs that can contribute to solving the prospective oil shortfall. The indicated directions are much the same for other W.A.E.S. year-2000 cases.

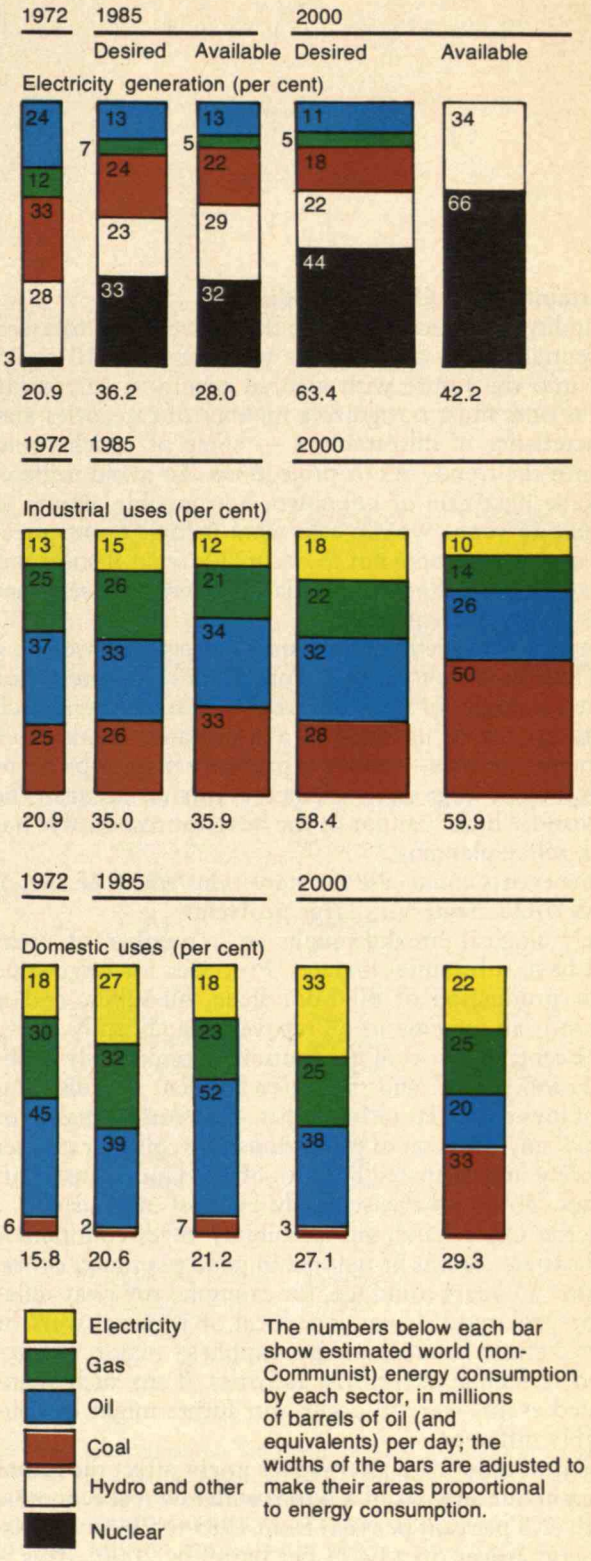
The chart illustrates the fuels desired and available in the year 2000 in three worldwide demand sectors: electricity generation, the domestic sector, and the industrial sector. The left-hand set of bars in each pair shows the preferred fuels — the total of national demands and preferences for fuels, assuming rapid economic growth and rising energy prices. This gives the *demand-preferred mix*. The right-hand set of bars in each diagram is an attempt to match the demand for primary energy to the available fuel supply. This is the *supply-constrained mix*, in which consumer demand is shifted between fuels according to supply and in order to use fuels in more efficient ways. For example, the only way to meet industrial and domestic demand for limited fossil fuels in the year 2000 is to eliminate their use in power plants, where coal and oil are burned at about 35 per cent efficiency. Notice also that global supply constraints result in a clear shift from oil to coal in the industrial sector; gas and electricity use are largely unchanged.

Changes in the domestic sector, given these allocation rules, are a bit more severe. Electricity use is reduced —although, even with supply constraints, it accounts for 22 per cent of the domestic market in 2000, or some 3.6 million barrels of oil (equivalent) per day higher than in 1972. Gas use is nearly the same as the demand-preferred level. Coal, however, enters in substantial amounts to replace oil. This result, which clearly and substantially violates consumer preferences, results directly from coal, not oil, being the fuel widely available.

We recognize, of course, that under different assumptions about economic growth and fuel prices the prospective shortages of oil might be reduced or eliminated. For example, economic growth may be forced to lower levels than we have assumed. This could have important repercussions on all countries, but the largest effects may be on the developing countries because of their dependence on trade with and aid from the industrialized regions of the world, and their inability to pay higher prices.

Or energy prices could go higher than we have assumed. Higher prices — so long as the increases are gradual, controlled, and foreseen — could encourage energy savings, stimulate the development of alternative fuel supplies, and reduce total energy demand so that consumer preferences are largely fulfilled.

But cases that eliminate prospective shortages would not change our consensus view — which is that the world must act on oil replacement systems with a sense of urgency. Any scenario which moves the prospective shortages beyond the year 2000 only serves to delay the time when severe dislocations could occur. Such "delaying tactics" do not eliminate the problem, nor can they be implemented without great costs.



The numbers below each bar show estimated world (non-Communist) energy consumption by each sector, in millions of barrels of oil (and equivalents) per day; the widths of the bars are adjusted to make their areas proportional to energy consumption.

Uncertainties and Other Hypotheses

The ability to foresee that some things cannot be foreseen is essential. There are no seers who can look 10 or 25 years into the future with assured accuracy. Any study such as ours must recognize a number of categories and characteristics of uncertainties — some of which could overturn the trends in our projections. To avoid neglecting some uncertain or unknown, but possible, events of the next 25 years, we can ask: what if some events presently anticipated were not to occur? Or what if some unexpected events should take place? In either case, what might be the consequences?

The W.A.E.S. methodology and analysis are based on a set of futures without large discontinuities — either major new technologies or large interruptions or disasters. Such factors cannot be included in a systematic, quantitative way in the analysis — and it is probably inappropriate to try. Although large unanticipated events do occur in the real world, "luck" cannot be the basis for responsible national policy planning.

Some events could ease the transitions which lie ahead. Others could create very large problems.

Technological breakthroughs in a number of areas could have substantial impacts. Processes for large-scale *in situ* production of oil from shale, oil sands, and/or heavy oil; an increase in oil recovery significantly above 40 per cent; *in situ* coal gasification; commercially available fusion power; and rapid development and distribution of low-cost solar technologies — all could "make" or "break" any given set of projections. We consider it wiser to classify unanticipated bonuses of this kind as just that: bonuses. To do otherwise would be most imprudent.

On the other hand, the possibility of discontinuities and disasters cannot be ignored in good planning, either. The next 25 years could see, for example: runaway inflation or prolonged depression; local or regional wars or coups d'etat affecting energy supplies; major energy-related accidents; or terrorist activities. If any such unanticipated events were to occur, our future might be considerably different.

A hint of how some alternatives might affect the future is given in our analysis of a future with low real economic growth (2.8 per cent per year from 1985 to 2000) and rising energy prices (to $17.25 per barrel by 2000). This is a "low-demand/high-supply" case — at least relative to the other W.A.E.S. cases studied.

Under these assumptions, we find that oil and gas are probably sufficient to meet preferred demands for these fuels in the year 2000. This result assumes, of course, the W.A.E.S. "high" (45 million barrels per day) estimate of O.P.E.C. production; oil is still, in this case, the most important global fuel. The small margins of deficit or surplus in this case are probably well within the limits of uncertainty of the numbers themselves. Yet even if this case does balance — even if potential supplies are in fact sufficient to meet desired demands in 2000 — this case just stretches the time-scale. The same mismatch between supply and demand as in other cases appears by 2005 or 2010 in the analyses. This postponement might allow more time for the eventual transition, more time to develop new technologies and renewable energy forms. But these technologies must be developed and this time must be used.

The Critical Years Are Now

The years through 1985 are critical ones. Events and policy decisions in the decade before 1985 will determine success in demand reduction, fuel substitution, or additions to supply in the 1985-2000 period. We are, in 1977, on the threshold of a critical decision period. We cannot afford to waste the years immediately ahead if we are to have any large-scale energy options available before the end of the century. The time for decisive action is now.

Actions are required on a large scale to avoid shortages. The size of the gap is large and its inception is soon. Balancing energy supply and demand by 2000 in an acceptable manner will require great effort. The alternative could be severe economic and political dislocations resulting from sharp energy price increases and perhaps other, more difficult events.

The period from now to the end of the century must be one of energy transition — away from oil as the world's dominant fuel. For this to be a smooth transition, greater international cooperation among increasingly interdependent nations is essential. Vigorous research, development, and demonstration of new supply sources, conservation, and fuel-switching programs must move forward quickly on an international scale. The timing of future energy-related programs and plans must take account of the challenges of this critical period. Our energy world then and in the 21st century depends on it.

References

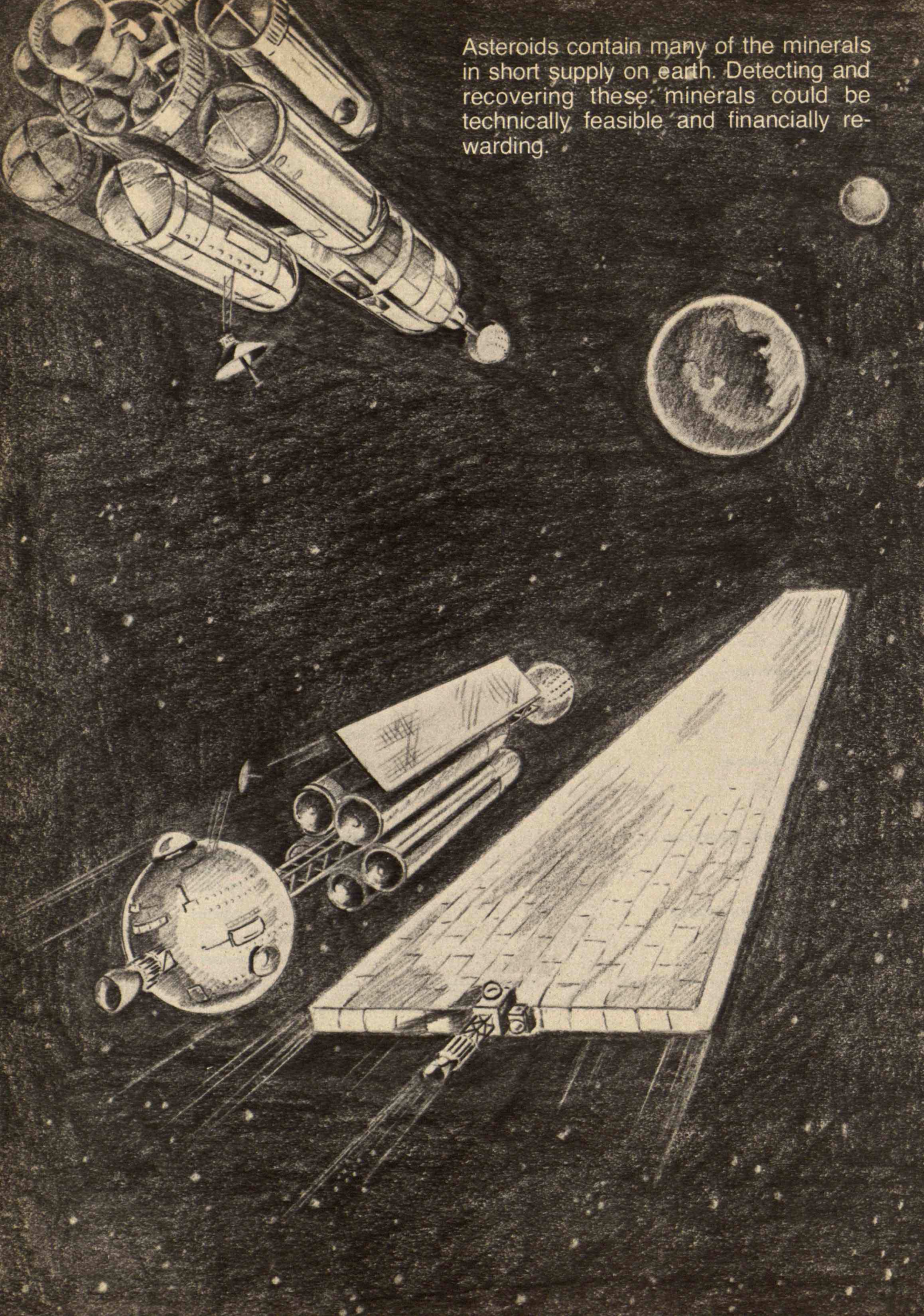
In addition to the principal report of the Workshop on Alternative Energy Strategies from which this article has been developed (*Energy: Global Prospects 1985-2000*; New York: McGraw Hill, 1977, $14.95 in cloth, $6.95 paperback), three technical volumes contain much of the

W.A.E.S. analyses of future energy supply and demand are based on the key global variables combined into the scenarios (cases) shown in this table. Analyses of the situation to 1985 made it clear that Case E was inconsistent — demand far outran supply before 1985 — and that the high prices postulated in Cases A and B would result in substantial energy surpluses — and presumably severe economic dislocations — in 1985. Studies of Cases C and D, in which demand and supply were closely matched in 1985, were continued to 2000. All energy prices are per barrel of Arabian light crude oil, f.o.b. Persian Gulf, or equivalent, in 1975 dollars.

	Case A	Case B	Case C	Case D	Case E
1977-1985:					
Economic growth rate	High: 5.2% per year	Low: 3.4% per year	High: 5.2% per year	Low: 3.4% per year	High: 5.2% per year
Energy price (see caption)	Rising: $17.25	Rising: $17.25	Constant: $11.50	Constant: $11.50	Falling: $7.66
National energy policy response	Vigorous	Vigorous	Vigorous	Restrained	Restrained
1985-2000:					
Economic growth rate			High: 4.0% per year	Low: 2.8% per year	
Energy price			Rising: $17.25	Constant: $11.50	
Additions to oil reserves			High: 20 billion barrels per year	Low: 10 billion barrels per year	
Maximum O.P.E.C. oil production			High: 45 million barrels per day	Low: 40 million barrels per day	
National energy policy response			Vigorous	Vigorous	
Principal replacement fuel			Coal or nuclear	Coal or nuclear	

detailed analysis upon which the W.A.E.S. findings are based. These are *Energy Demand Studies: Major Consuming Countries* (1976), *Energy Supply to the Year 2000: Global and National Studies* (1977), and *Energy Supply-Demand Integration to the Year 2000: Global and National Studies* (1977). All three have been published in the years indicated by the M.I.T. Press, Cambridge, Mass.

Paul S. Basile joined the staff of the Workshop on Alternative Energy Strategies two years ago, and he was the Editor of its first report, *Energy Demand Studies: Major Consuming Countries* (Cambridge, Mass.: M.I.T. Press, 1976). He is now associated with the Energy Program at the International Institute for Applied Systems Analysis in Laxenburg, Austria. Mr. Basile first came to M.I.T. following undergraduate studies at Princeton in 1970; he holds Master's degrees from the Institute in aeronautics and astronautics (1972) and management (1975). **David Sternlight** has been an associate of W.A.E.S. since the project's inception, and he is the principal architect of its overall methodology and of the constrained supply-demand integration model. Following undergraduate work in economics at M.I.T. (S.B. 1960), Dr. Sternlight studied at the London School of Economics (Ph.D. 1962); he worked at Rand Corp., I.B.M., and Litton Industries and was Deputy Director of the Office of Policy Development in the Department of Commerce (1975-76) before taking his present post.



Asteroids contain many of the minerals in short supply on earth. Detecting and recovering these minerals could be technically feasible and financially rewarding.

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Mining Outer Space

We on earth face a dismal and inevitable future of decreasing mineral resources. As our search for minerals becomes wider and more frantic, we are forced to use ores of ever lower grades. Even before the easily available terrestial deposits of many metals such as copper, nickel, and iron are completely exhausted, the economic and environmental costs of discovering and developing low grade ores will become prohibitive.

Without the basic resources our civilization requires, the standard of living for most of us on this planet will inevitably decrease. Perhaps before supplies are exhausted we will have so drastically polluted and disrupted our environment that life will be very difficult.

The answer to our mineral shortages may not lie on earth at all, but in space. The earth is only one of a large number of objects — the planets, satellites, asteroids, comets orbiting the sun — which were formed of similar material in similar ways to the earth. Thus these objects may harbor familiar resources.

We find the prospects of detecting and recovering resources from these extraterrestial bodies to be exciting and unexpectedly reasonable.

The need for new resources is not restricted to the earth's surface. Raw materials will also be needed to construct and operate near-earth solar power stations, factories or other installations. To use materials which need not be lifted out of earth's deep gravity well would be much more economical.

How Space Minerals Originated

Approximately 4.7 billion years ago, a spinning cloud of gas and dust contracted to form our solar system. The early sun heated the embryo solar system, evaporating the volatile materials in close proximity, and driving others to the outer solar system or beyond. The larger planets and satellites, heated through their rapid accumulation and by the decay of naturally radioactive elements, were at least partially melted. Thus the early solar nebula produced separate objects of differing composition.

The minerals and metals valued on earth might, then, be found in other solar system objects. Assuming that the sun, because of its huge mass, still retains the original composition of the primitive solar nebula, it is possible to estimate the types of materials found in the solar system and their distance from the sun. The least volatile materials should be found at their lowest oxidation state closest to the hot sun in the areas containing the terrestrial planets: Mercury, Venus, Earth, and Mars. More volatile materials should have survived further from the sun in the colder outer solar system near Juipter and beyond. Cold conditions throughout the formation process would have prevented the complex melting and remelting required to create many of the highly evolved minerals found on the differentiated earth. The more massive objects with stronger gravity fields would retain more of the lighter and more volatile materials against the solar heat. Thus we know that the setting is right for the existence of material resources like those found on earth or other inner solar system objects. But whether certain specific ores are present requires more direct investigation.

Metal ingots formed at the asteroid mining facility are shaped into large "rafts" and sent by space tug to a refinery in orbit around the earth. There the ingots will be remelted to form the foam-metal components of the atmospheric entry body, and sent to earth. (Drawing: Robert Ullrich)

Space Prospecting

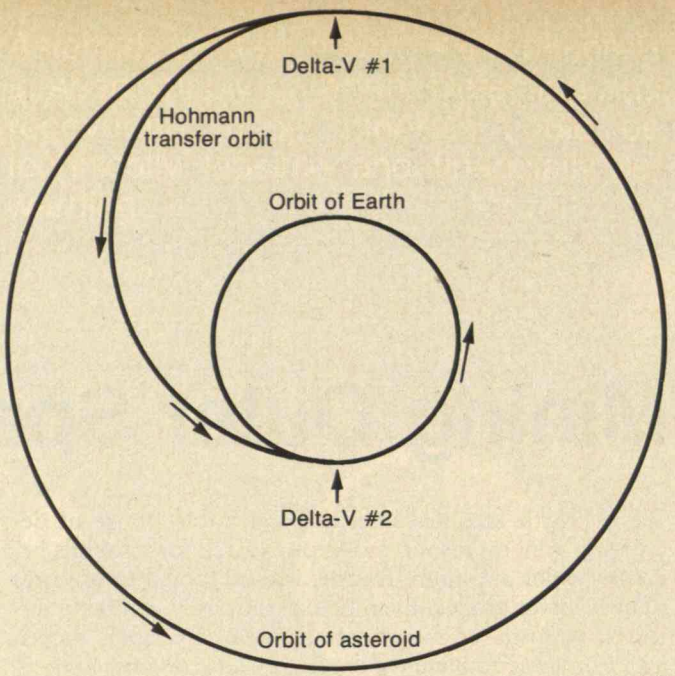
The best way to determine the composition of materials in an object is to obtain samples and analyze them. The earth's surface presents no problem in this respect; and eight sites on the moon have been analyzed. But, justifications for sending prospecting spacecraft to other solar system objects are difficult to make without some prior specific information on the likelihood of a successful return on the investment.

Without direct sampling, one must rely on remote sensing techniques to probe for surface expressions of needed materials. Earth-based telescopic techniques cost the least; spacecraft-borne experiments carried out on fly-by or orbiting missions cost considerably more. Remote sensing techniques using earth-based telescopes have already revealed the existence of nickel-iron objects within the asteroid belt, as well as objects rich in carbon compounds. Lunar samples returned in the Apollo Program from several sites revealed titanium-rich rocks. Remote sensing techniques, again applied from earth, have mapped vast extents of these titanium-rich deposits across moon's surface.

From earth, one can observe only electromagnetic radiation. Fortunately, sunlight reflected from surface materials does contain information about composition. Electrons in mineral crystals absorb sunlight at certain energies; the kinds of ions present in the crystal and the crystal structure control the absorption energies; and these properties define the mineralogy. By measuring the spectrum of reflected sunlight and searching for absorp-

This page: The most energy-efficient way to move material from one orbit to another within the solar system requires that a change in velocity (Delta-V #1) convert the original orbit into an elliptical transfer orbit tangent to the final orbit, and that another change in velocity (Delta-V #2) convert the transfer orbit to the final orbit. The elliptical transfer orbit, tangent to both the initial and final orbits, requires the minimum energy and is termed a Hohmann transfer orbit.

Opposite page: A schematic representation of a possible trajectory for a lander to travel from factory to earth is shown. Lunar gravity is used to modify the original orbit into earth-encounter trajectory with a minimum of energy expenditure.



tions at specific wavelengths, one can often determine which minerals compose the surface of solar system objects.

We have used reflectance spectroscopy to analyze the minerals in a number of solar system objects, the most interesting of which are the asteroids.

The reflectance spectra of well over 100 asteroids have been measured and the surface composition of many tens of asteroids seems well determined. Among these asteroids are many metal-rich objects which are possible sources of useful raw materials.

The best analysis of available asteroid spectral data indicates that about half of the inner belt asteroids have metal-rich mineral assemblages on their surface. Asteroids of smaller diameters (about 1km) probably also contain a high relative abundance of metal-rich mineral assemblages. The asteroid reflectance spectra can not yet tell us the exact composition of the free metal phases: we do know that the bulk of the metal is iron, but the observations can not discriminate between the low and high nickel types of Fe-Ni metals and the intermediate nickel types. We assume the composition of the metal phases in the iron, stony-iron and stony meteorites to represent a reasonable set of limits on the range of variation.

The Grubstake and the Return

Obviously, we will be able to mine extraterrestrial resources for earth use only if they are both retrievable and profitable, both economically and socially.

First we will discuss the possible profits, considering only the metals of the nickel-iron series found in meteorites; specifically, we will consider the potential value of a very small asteroidal mass containing one cubic kilometer of Ni-Fe metals, delivered in marketable condition to the earth's surface.

A simplistic analysis indicates a gross value of approximately $5 trillion, or about five times the United States gross national product, for an asteroidal body containing one cubic kilometer of meteoritic metal. (Such a return cannot be realized in an actual marketplace, however, since the supply would far exceed the demand.)

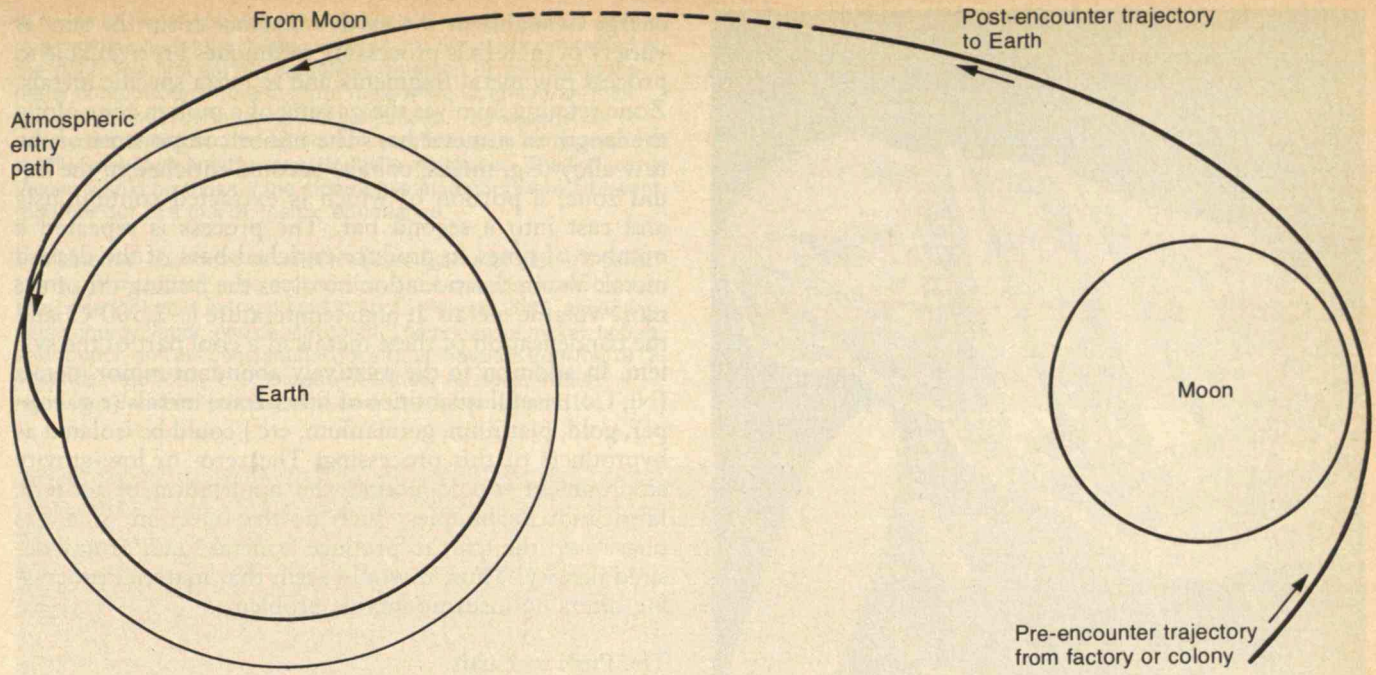
The asteroid's nickel content would provide approximately two-thirds of its potential monetary value, and represent a nickel supply for more than a millenia at present terrestrial use rates.

Present consumption rates are largely governed by the local standards of living, and the relative abundance of these metals. The high per-capita consumption of iron is a result of its abundance and hence low price. If nickel were a much more common metal, it would be substituted for and alloyed with iron to take advantage of its metallurgical characteristics, such as corrosion resistance. We can probably assume that if the supply of nickel was large and the price were about twice that of iron, there would be a market for nickel at least 10 per cent that for iron.

The future consumption rate of iron depends on population growth, living standards, and mining and recycling technology. Let us assume that any increase in total iron consumption due to population growth and/or increase in the average standard of living is offset by increased recycling. The worldwide consumption of "new" iron might thus remain at its present level into the future. (This projection, however, may be as much as an order of magnitude underestimated.)

The price structure for "new" iron at some point in the future is somewhat easier to predict. The cost to produce iron from raw ore depends on the capital costs of expanding, maintaining, or replacing plant facilities to accomplish the actual processing, and on the operating costs of mining, transporting,and smelting the ore. The latter are closely tied to energy costs. For example, the smelting process requires approximately one ton of coke to convert 1.5 tons of ore to one tone of iron. As we are forced to rely more upon low grade ores which require larger volumes or raw ore, more concentration steps, larger waste disposal activities, and significantly larger pollution abatement and land reconstruction activites, the operating costs of producing "new" iron will almost certainly equal or exceed the inflation rate.

These two factors imply that the sale price of iron at any time in the future will maintain at least a constant uninflated dollar value. It is more likely that the price, in 1975 dollars, will increase by 50 to 200 per cent. We assume, for purposes of our analysis, that the price of iron,



in 1975 dollars, will double.

Our final assumption is that the rate of delivery of these metals will be limited, by physical constraints, to only half of the demand for "new" iron. We can then calculate the economic return from this venture (*see page 56*).

We project an annual return of at least $140 billion. This would require a delivery rate of 650,000 metric tons per day for iron and 135,000 metric tons for nickel. We will discuss the implications and feasibility of such a delivery rate in the next section.

In a more conservative economic scenario in which the rate of delivery to the surface of the earth is sharply constrained (e.g., 1 to 10 per cent of the previous figures), the major economic benefit is derived from the nickel phase: a delivery rate of 10,000 to 50,000 metric tons per day, and an annual market of $20 to $100 billion per year.

Sparing the Earth

The major non-monetary benefits of using extraterrestrial resources are ecological and political, and, while they are easy to define, they are difficult to quantify. We do know, however, that the mining of low grade ores can have severe ecological effects.

Mining appears to be taking an ever increasing environmental toll. For example, in 1972, 450 million metric tonnes of coal, or approximately 15 per cent of world coal production, was consumed to smelt 750 million metric tonnes of iron ore to produce raw iron. Whereas in new mines, such as Iron Mountain in Australia, the ratio of material mined to ore shipped is about 1:1, older iron ore districts, such as the Mesabi Range in Minnesota, at best produce a ratio of about 2.5:1. In the Mesabi Range the high-grade surface ores have been exhausted, and lower and lower grade material is now mined and its iron oxide content isolated and concentrated. The taconite operations in the Lake Superior District, which in 1972 produced 71 per cent of U.S. ore, use this procedure. The average recoverable iron content of crude ore mined was 24.4 per cent, which requires the disposal of 1.5 tons of waste for each ton of ore produced.

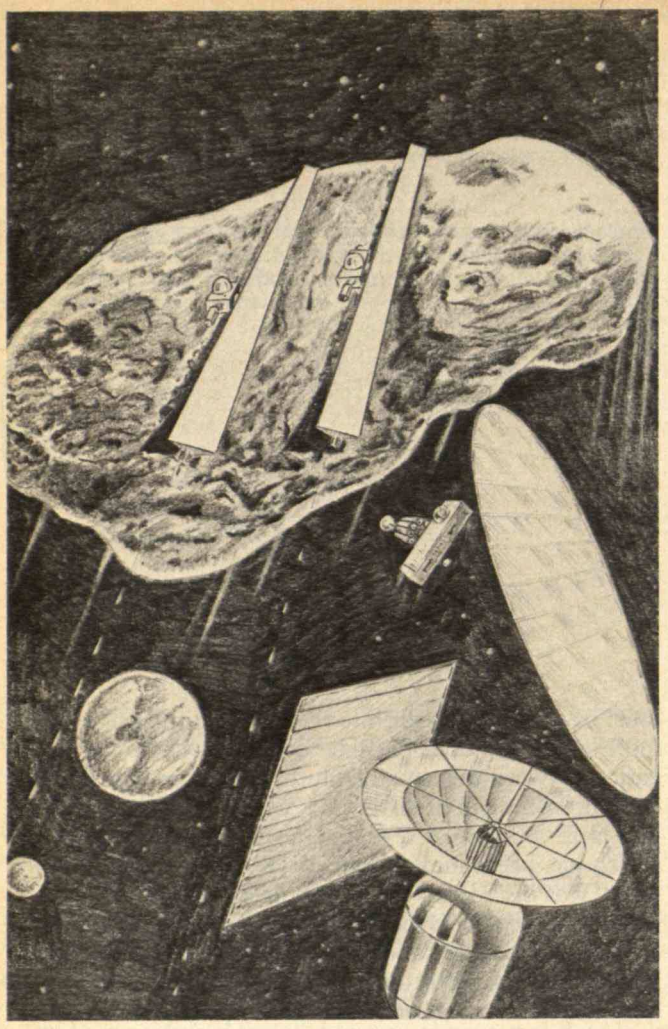
As the recoverable iron content of the crude ore decreases, more material must be excavated, more energy must be used to concentrate the iron bearing phases, and more waste material must be disposed. The present litigation between the city of Duluth, Minn., and the Reserve Mining Company of Silver Bay, Minn., is a case in point. The large amount of very fine particulate waste material, which has been dumped into Lake Superior for over ten years, was discovered to contain an asbestos-like mineral. This mineral was suspended in the lake and was carried 50 miles to Duluth, and contaminated the water supply. Legal action, subject to exhaustion of all appeals, now requires that the waste materials be disposed of on land in special ponds, at a significantly higher operating cost.

This experience is instructive. The environmental costs *or* the financial costs of negating the environmental damage increase significantly as the grade of the crude ore decreases. These costs must be paid in a lowering of the quality of life *or* an increase in the cost of materials *or* both. Recent public reaction to similar choices has shown the second alternative to be the least offensive.

We emphasize that we are not discussing the exhaustion of these sources. Total iron reserves are effectively infinite (3 to 5 per cent of crust, 35 per cent of total earth). This discussion centers on the exhaustion of easily accessible or high-grade deposits which can be exploited at a low environmental and financial cost. In this case, extraterrestrial sources for certain materials can bypass these costs.

The political benefits of extraterrestrial mining stems from the distribution of the highest grade reserves (least exploited and hence cheapest) around the world. Most of these reserves are located in the underdeveloped areas of South America, Africa and Asia. The developed countries are exhausting their domestic sources of environmentally and financially inexpensive ores. The Third World, rising nationalism, and the advent of raw material cartels, such as O.P.E.C., signal a period of confrontation between the producer and the consumer nations over supplies of these raw materials.

Extraterrestrial sources of materials represent an alternative source of materials, and one without the high environmental costs. However, at this time there exists no legal basis for acquiring and using materials beyond one



An asteroid is moved into an orbit near earth. There miners who live in colonies in space will use large solar mirrors to melt and refine metal from the mining asteroid. The metal will be formed into ingots and stored for eventual transfer to a space factory in orbit around the earth. (Drawing: Robert Ullrich)

country's bounadries. Arrangement made for sea floor material utilization would probably be a reasonable basis.

Spacing Mining Techniques

The use of abundant solar energy to refine and process the material while it is still in space would decrease the terrestrial demand for energy as well as the pollution arising from processing. Of the three types of objects — materials similar to iron meteorites, stony-iron meteorites, and ordinary chondrites (stony meteorites containing 3 to 20 per cent iron) found in the asteroid belt — only the ordinary chondritic materials require significant concentration of the Ni-Fe-Co phases. This can be accomplished by the simple process of crushing the material and magnetically extracting the metallic minerals from a ballistic stream.

A large mirror focusing sunlight on the aperture of an insulated cavity can raise the temperature of the cavity to several thousand degrees. One can envision a slowly moving stream of crude metal fragments entering one side of the cavity, and a continuous bar of metal being withdrawn from the opposite side. Approximately 150 metric tonnes of Ni-Fe-Co mineral fragments could be melted per square meter of mirror area per year using the solar energy available at the earth's distance from the sun. A variety of materials processing techniques are available to process raw metal fragments and to extra specific metals. Zone refining involves the passing of a molten zone along the length of a metal bar. The minor components of the raw alloy (e.g. nickel, cobalt) become enriched in the liquid zone, a portion of which is extracted continuously and cast into a second bar. The process is repeated a number of times to produce enriched bars of the desired metal. Vapor fractionation involves the boiling off of the more volatile metals at high temperature (~2,500°C) and the condensation of these metals in a cool part of the system. In addition to the relatively abundant minor metals (Ni, Co), useful quantities of other trace metals (e.g. copper, gold, platinum, germanium, etc.) could be isolated as byproducts of this processing. The zero- or low-gravity environment would permit the application of esoteric fabrication techniques, such as the injection of a gas phase into the melt to produce a metal foam of any desired density. Thus, it would seem that material processing offers no insurmountable problems.

The Push to Earth

Transport problems will be the knottiest. A scheme must be devised to move this material from some point in the solar system to near-earth space and from near-earth space to the surface of earth. Whatever techniques are employed must have no significant adverse environmental effects, and must be within the present or projected state of the art.

Before the various transportation options are discussed, it is enlightening to consider the relative energy requirements for the terrestrial and extraterrestrial cases. In order to smelt high-grade iron ore (iron oxide) to metal in a blast furnace, about 17 megajoules of energy (from oil, coal and natural gas) are needed to produce each kilogram of iron metal. The energy expenditure (in an efficient transportation system) required to move metal from an asteroidal source to near-earth space is between 5 and 100 megajoules per kilogram, depending on the initial orbit. Thus the energy expenditures are comparable in either case.

To transport a large mass of mined metal from the asteroid belt to earth, two separate velocity changes will be needed. The first is needed to push the mass out of its original orbit around the sun and into a transfer orbit that will take it near earth. The second thrust is that required to change the transfer orbit into a final orbit about the earth. The transfer orbit requiring the least energy is one called a Hohman orbit, and is tangent to both the initial and final orbits *(see page 52)*.

There are a number of technically developed or feasible methods of modifying an orbit. These represent a range of techniques applicable to moving objects over a wide range of sizes and timescales. The utility of any particular orbit modifying technique can be judged on the basis of several additional criteria, including the nature of the fuel and the simplicity and reliability of the technique. Any reaction system which requires a sophisticated working fluid (e.g. cesium, liquid hydrogen and oxygen, etc.) in large quantities which must be supplied from a distant source (e.g. the surface of the earth), will probably have limited use. A system that can use any type of material as reaction mass is strongly preferred. Also, any system should be reliable and require the minimum of sophisticated maintenance. Some of these orbit modifying tech-

In terms of metal-rich asteroid materials, one can provide several approximations for the metal composition. Three are presented at the right. The first set of values was obtained by averaging the metal compositions from the iron meteorites weighted for their relative abundance in terrestrial collections. The second set of values are based on the equilibrium crystallization composition of the Ni-Fe system and the range found in meteorites. The final set of values would be those if the siderophile elements were all swept together out of a mix of cosmic abundance.

Metal	Average meteorite (per cent)	Equilibrium crystallization (per cent)	Cosmic abundance (per cent)
Iron	88.4	89	95
Nickel	8.7	10	4
Cobalt	0.61	0.6	0.27
Copper	0.10	0.1	0.16

The potential economic value of a square kilometer (about 8 billion tonnes) of meteoritic or asteroidal nickel-iron metal is shown below. The price for iron is extrapolated to about the year 2000, assuming rising energy, labor, and capital costs. The prices for nickel, cobalt, and copper, and the consumption for all four metals is from the 1973 *Minerals Yearbook*, U.S. Bureau of Mines. All dollar values represent constant purchasing power dollars (uninflated).

Metal	Per cent	Mass (million tonnes)	Price (dollars per million tonnes)	Value (dollars per million tonnes)	Use rate** (million tonnes per year)	Years supply
Iron	89	6.9×10^9	200*	14×10^{11}	4.5×10^8	15
Nickel	10	0.8×10^9	4400**	35×10^{11}	6.4×10^5	1250
Cobalt	0.5	4×10^7	8800**	3.5×10^{11}	2.0×10^4	3000
Copper	0.1	8×10^6	1380**	$.11 \times 10^{11}$	$.8 \times 10^6$	1
				5.3×10^{12}		

* "Pig Iron to Heavy Scrap," *Iron Age*, Vol. 216, 1975, p. 48
** *Minerals Yearbook*, U.S. Bureau of Mines, 1973

niques include:

a) *Rocket: Chemical* — The standard rocket (e.g. Saturn V) burning chemical fuels (e.g. hydrogen and oxygen) has a rather low efficiency and can deliver only a small fraction of total vehical mass as payload over a significant ΔV step. It should have limited small-scale applications in special circumstances.

b) *Rocket: Nuclear, Light Element* — In this type of reaction engine, the exhaust energy is supplied by a nuclear reactor rather than by a chemical reaction. The exhaust (e.g. H_2) operates at higher temperatures and therefore is more efficient. This is a reasonably developed technique (e.g. Project Nerva and Project Dumbo).

c) *Rocket: Nuclear, Heavy Element* — This type of theoretical reaction engine would utilize a fusion reaction to vaporize any available reaction mass (e.g. rocks, waste, etc.) to provide exhaust. This would seem to be a reasonably efficient system if it can be developed.

d) *Nuclear Impulse: Ablative* — The detonation of a nuclear device above (~100m) the surface of a small body (~500-5,000m) produces a transient plasma crater and plastma jet-away from the surface resulting in a small ΔV for the body. A large number of impulses are required for any significant ΔV, but total cost is small compared to the value of the body in most scenarios. However there is a possible problem of contamination of the surface layers of the body with radioactive materials. This technique is applicable to modifying the orbits of small, relatively strong asteroidal bodies.

e) *Nuclear Impulse: Non-ablative* — The detonation of a nuclear device produces a shockwave (plasma shell and photons) whose momentum can be transferred to a vessel by a "bumper." This reasonably well developed technology can provide relatively cheap transportation for very massive vessels, but may create a problem with radioactive waste.

f) *Ion Rocket* — The ions of certain materials (e.g. cesium, mercury) are accelerated in an electrical field to produce a very high velocity exhaust. This well developed technique is a low thrust system, requiring both an energy source and specialized reaction mass and would be applicable to long-term, low-thrust missions for small payloads.

g) *Charged Particle Rocket* — This proposed system, in which submicron grains are electrically charged (e.g. photoionization in silicate grains) and accelerated to produce exhaust, has a potentially significant thrust, and can utilize *in situ* material as reaction mass. It would require a separate energy source.

h) *Transport Linear Accelerator* or *Mass Driver* —Thrust is produced by acceleration of reaction mass (in reusable "buckets" along a track by dynamic magnetic levitation and a linear synchonrous motor. The total thrust is low, but any material can be used as reaction mass. An energy source would be needed, and provisions must be made for continuous maintenance of the TLA components. This is a developed system.

i) *Laser Propulsion* — The energy from an external energy source (fission or fusion reactor, solar collector) can be transferred via laser beam to the object or artifact

The amounts of asteroidal material delivered to earth in the next century will have an effect on their projected economic return. The return, assuming a high delivery rate (about 800,000 mt/day), providing half the terrestrial demand for "new" iron (assumed to equal present demand), and all of the demand for nickel at a higher use rate (10 per cent of iron), is shown above. Assuming a relatively low delivery rate (10,000 to 50,000 mt/day) primarily for nickel at the current price level ($5/kg), and assuming that nickel becomes cheaper in relation to competing metals to increase world demand (from about .2 kg per person per year to up to 5 kg per person for year), the results are shown at right.

Metal	World demand (million tonnes)	Supply (per cent)	Price (dollars per million tonnes)	Value (1975 dollars)
Iron	5.0×10^{8}	50	400	1.0×10^{11}
Nickel	0.5×10^{8}	100	800	0.4×10^{11} / 140×10^{9}

Metal	Consumption per capita (kilograms per year)	World population	Price (dollars per kilogram)	Annual market value (dollars)
Nickel	1	4×10^{9}	5	20×10^{9}
Nickel	5	4×10^{9}	5	100×10^{9}

to be moved. Surface material of a small body can be vaporized to produce exhaust *or* the beam can be directed into an engine cavity to vaporize specialized reaction mass (e.g. H_2O, O_2). This is a reasonably well developed technology.

j) *Solar Sails* — The momentum carried by sunlight can be transferred to an object by reflection of the light off of a large, low mass collector or sail. Large (e.g. 50 km diameter), state-of-the art (very thin metal films supported by a fine wire grid) solar sails, fabricated in space, offer a method of moving large cargoes (e.g. a million metric tonnes over significant velocity increments (e.g. 10 km/sec) in relatively short time intervals (e.g. one year). Once deployed, such a sail requires neither reaction mass nor energy source and is both easily controlled and insensitive to space erosion (e.g. micro meteorites) for a reasonable lifetime (e.g. 25 years).

k) *Collisional Impulse* One or more of the above techniques could be used to perturb a smaller body (~1/1,000 mass) into a collision with a larger body to be moved. At relatively low collision velocity (e.g. 1 to 3 km/sec), significant momentum transfer (and orbit modification) could take place without disrupting the larger body.

l) *Gravitational Assist Trajectory* — A close encounter with a planetary mass would permit a momentum transfer between the object and planet, modifying the orbit of the object (e.g. trajectory change of Pioneer 10 and 11 spacecraft during Jupiter fly-by). The magnitude of the resulting ΔV is a function of the mass of the planet encountered, and the maximum ΔV can be obtained for only one orbital configuration. Encounters with the earth, moon and Mars are likely to be the most useful for our purposes. This mechanism is especially useful in modifying the eccentricity or inclination of an orbit. This is a rather powerful technique requiring precise guidance and control.

m) *Atmostpheric Graze* — Velocity relative to a planet can be decreased by allowing the object to pass through the outerfringes of the planetary atmosphere so that atmospheric drag acts on the object. The total ΔV depends on the size, shape, and density of the object and on the path through the atmosphere and on velocity with respect to the planet. This technique is limited to small coherent bodies and artifacts and requires very precise guidance and control. For massive objects such as small asteroids, this technique can be used only where no danger to populations is present (e.g. Mars, Venus). It is applicable (and used) to slow spacecraft and fashioned artifacts (atmospheric entry bodies) for landing on the earth's surface.

The methods for modifying the orbit of a body or vessel discussed above represent a range of options. For moving small asteroids, Nuclear Impulse - Ablative, Collisional Impulse and Gravity Assist appear to be the most promising. For vessels or cargoes, Heavy Element Nuclear Rocket, Nuclear Impulse - Non-albative, Mass Driver, Laser Propulsion, Solar Sails, Gravity Assist, and Atmospheric Graze all offer reasonable methods. The relative merits and final choice(s) will depend on a variety of technical, economic and social considerations. It is not our purpose to make a decision but merely to point out the wide range of available options.

Landing the Ore

Once in earth orbit, space-mined metal must then be brought down from high orbit (at 60 earth radii) to the earth's surface. As in the previous case, two braking thrusts are required, the first to lower the orbit and the second to finally land the material.

The first orbit change could be obtained by passing the object close to the moon, a maneuver shown schematically on page 53. This technique, however, will require a great deal of precision in the object's velocity and distance from the moon at encounter.

Until the point of atmospheric re-entry, the shape or character of the material mass hasn't mattered much, but now the nature of the mass becomes critical. We shall assume that the only braking on the mass of re-entering metal is atmospheric drag. We shall also assume that the mass can present no hazards to population or environment during re-entry. Thus, there can be little particulate material dumped into the upper atmosphere from a re-entering mass — and that the mass must land at a low ve-

locity in a safe region of the earth.

There are designs and re-entry paths, however, that will result in no loss of material, as is demonstrated by the non-destructive re-entries and landings planned for the Space Shuttle. Such a technique would involve a very low angle of re-entry into the earth's atmosphere of an object that has either a large cross-sectional area for its mass or a lifting-body-type design. The large-cross-section body can slow without losing material because the heating is spread over a large area. The lifting body decelerates along a long glide path, so as to spread the episode of heating over a long period of time. This way the temperature can be kept below the melting point of the material.

Our calculations show that for a zero-angle entry, with a lift-to-drag ratio of at least one-third, a body with a density of 500 grams per square centimenter of space area can reach the earth's surface without the surface of the body reaching the melting point of iron (1,800°K.) For such an atmospheric re-entry, the major source of loss should be chemical action — rusting — between the air in the boundary layer and the surface material of the body. This will be, however, very small. The shapes that would satisfy the requirements for a re-entry vehicle must be inherently stable upon re-entry, that is, the center of mass of the object is forward of the center of figure of the object. All can be actively controlled upon re-entry by shifting the center of mass internally. All have large surface areas with respect to their mass.

For example the "flattened shuttlecock," with a diameter of 150 meters, a lift-to-drag ration of one-half, and a mass density of 600 grams per square centimeter would reach a maximum temperature less than 1,800°Kelvin and would reach a maximum velocity in the lower atmosphere of about 100 meters per second. Such a body could deliver 100,000 metric tonnes of materials, at about $400 per metric tonne, for a total of $40 million.

Since the processing and fabrication of the entry vehicle is carried out in a zero-gravity environment, it is a simple matter to inject gas or volatile material into the molten metal at its last processing stage to produce a metal foam structure. The re-entry mass would, thus, be made up of material less dense than water which can be dropped into any large body of water and will float, even if it breaks upon impact. The low-density structural material is important for purposes of safety, in that if the structure should disintegrate during re-entry, the individual pieces will have very low terminal and impact velocities.

Life as a Space Miner

From these discussions we can imagine a future scenario for a space mining operation.

Mining colonies of up to 10,000 workers have been established on a few small, stony-iron asteroids (about ten kilometers), relatively close to the earth in terms of the energy required to land the material. These relatively self-sustaining colonies are closed ecosystems. They obtain those necessary materials which they cannot find on their home-base asteroid (e.g. hydrogen, nitrogen) from nearby asteroids (in terms of energy required) of low-grade carbonaceous-like material. For 12 to 18 earth months, the colonists carry out mining operations, melting and refining metals melted in large solar furnaces. Ingots are formed and waste material (primarily silicates) are stored.

At a time depending on relative orbital location of the asteroid, earth, and perhaps Mars, a large tug leaves the asteroid, pushing its cargo of nickel and iron ingots into a transfer orbit to the earth. Near the end of the year-long voyage, the optimum entry path is determined, with respect to the complex motions of the earth-moon system, in order to gain as much benefit as possible from gravitational interaction. The vessel and its cargo rendezvous with one of several very large space factories/colonies located in a resonant orbit about earth, about 100,000 km from the moon. The vessel transfers its metal cargo, takes on the smaller cargo of supplies for the colony, and begins the long trek back to the mining asteroid.

On the space base, the metal ingots are again melted to form the foam metal components of the atmospheric entry bodies. As each body is completed, the guidance computer and internal mass mover are installed, and cargo loaded aboard. Small tugs gently shove these bodies to arrange an encounter with moon some weeks hence. A small bevy of tugs coax the landing bodies into the optimum trajectory.

The lunar encounter lasts less than an hour. Once past the moon and lined up with earth, lunar, terrestrial, and space-based radar networks lock onto each lander and report on its path. Again the tugs orient each lander to encounter earth atmosphere at just the right altitude. As the earth approaches, the final adjustments are made. The tugs pull away from the lander, miss the atmosphere, pass around earth, and head back to repeat the process.

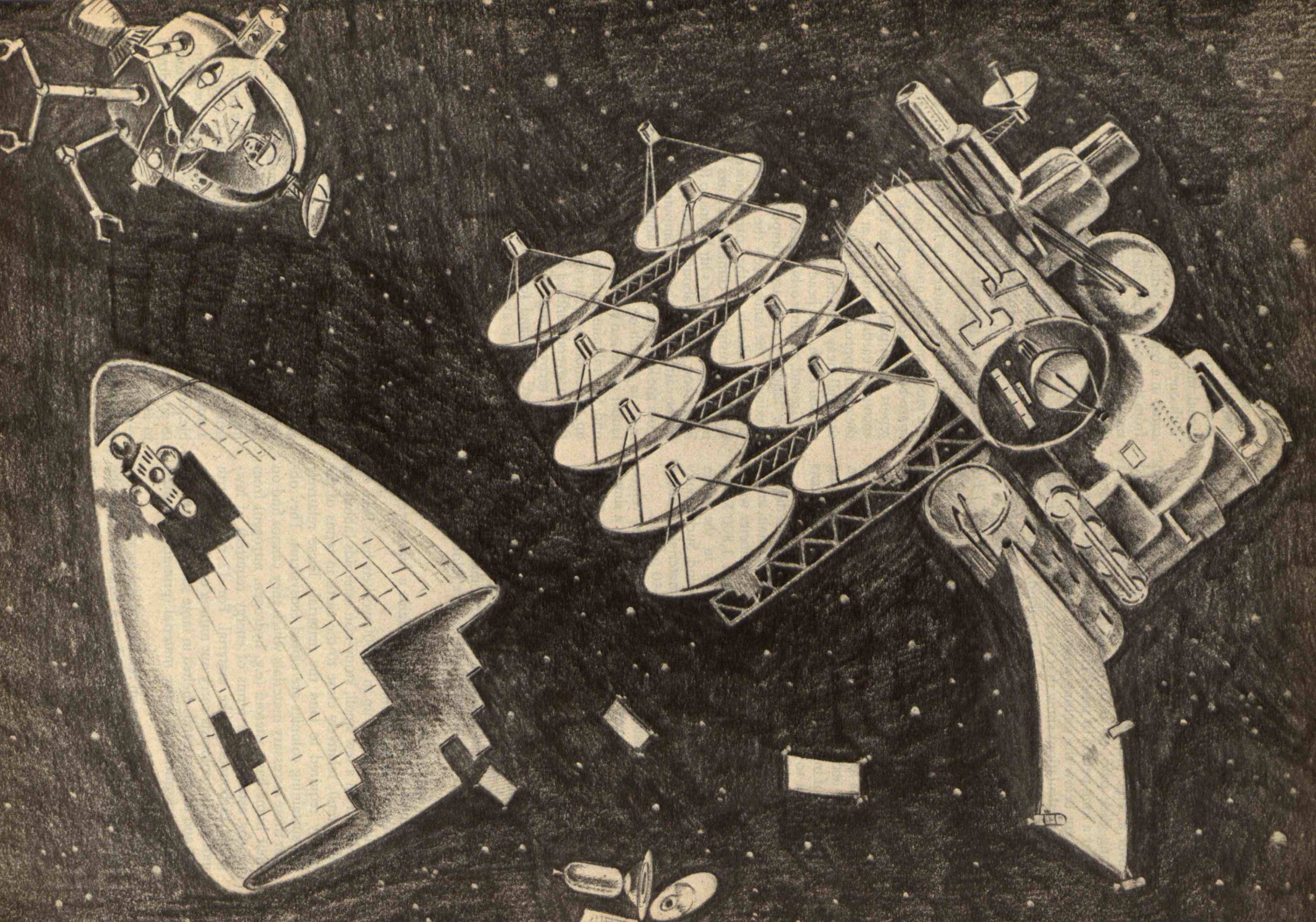
Ground, and low orbit stations are now in contact with the lander's onboard computers. Lift-to-drag at a maximum, the lander feels the first wisp of atmosphere and rotate slowly to the correct orientation, nose forward. Air resistance climbs as it sinks lower into the atmosphere. The lander's lift begins to flatten the orbit to a hypersonic glide at about 75 kilometers above the surface of the earth. The onboard computers, using updated data from the low orbit stations, adjust each lander's center of mass to stretch or shorten its projected flight path. The lander cools and settles as it slows to a kilometer per second. Several minutes later, the surface of the ocean rushes up, the lander nose hits the water, and a splash of water is thrown several hundred meters by the impact. The ocean-going recovery tugs wait a dozen kilometers away. A hundred thousand tons of pollution-free, energy-frugal stainless alloy is available for use.

The Knowledge Needed

Significant economic, environmental and political incentives exist for the utilization of extraterrestrial resources. No insurmountable technical problems should prevent such utilization. With this in mind, we make the following general recommendations to carry this concept forward:

— The compositions of asteroid surface materials should be verified by direct study of these objects from spacecraft. Such missions should carry instruments to determine compositions (reflectance spectrometer, gamma-ray and x-ray spectrometers, radar) and bulk properties (such as density and moments of inertia from spacecraft tracking). Soft landers or penetrometers might carry out *in situ* studies of the surface. A rover mission, which would visit a number of objects over several years, might be desirable. Ground-based studies should be continued in order to direct spacecraft targeting and to extend groundtruth to as many asteroids as is feasible.

— A continuous survey program should be undertaken or expanded to locate the small asteroids which cross or ap-



proach the earth's orbit. These objects offer special cases for which material transfer to the earth-moon system generally would require less energy than transfer from a belt asteroid. The surface compositions of these bodies should be investigated by the techniques described above.

In addition, development of advanced technologies and capabilities in at least four areas is required:

— Space transportation will require three innovations: a cheap, high-flux earth-to-orbit shuttle system; a space tug system for operations in near-earth and earth-moon space and for operations to and from the lunar surface; and a deep-space transportation capability for large-scale, long-term, high-mass manned operations in the Asteroid Belt and inner solar system.

— In the area of manned missions, it will be necessary to develop large-scale, long-term, self-contained closed life support systems; and systems (mechanical or biological) to permit long-term operations in zero or reduced gravitational fields without irreversible physiological damage.

— In the area of materials handling, we must: define the range of materials which will be encountered on the lunar and asteroidal surfaces; develop and evaluate techniques for concentrating and extracting the desired metals, oxides or minerals; and develop and evaluate fabrication techniques to produce structural elements for the space mining and manufacturing facilities and for the human habitats.

— In the area of construction, it will be necessary to define and evaluate techniques of assembling large-scale structures in low to zero-gravity, and high vacuum environments.

Economic studies of these proposals include initial investments required, return on investment, operating economics and impact on the terrestrial economy. Similarly, a study should be made of the political impact of this new material source on the economies and dependence patterns between the developed and the under-developed nations.

An international agreement will be needed to allow full use of resources from space.

We also need investigation and modeling of the technical, economic, physical and political interactions of space mining operations with space manufacturing facilities, power stations, and colonies and with the earth. It is probable that a multiple-use approach (mining, manufacturing, power production, and colonies) will provide a more sound economic, technical and political base on a shorter timescale and at lower cost than individual independent developments.

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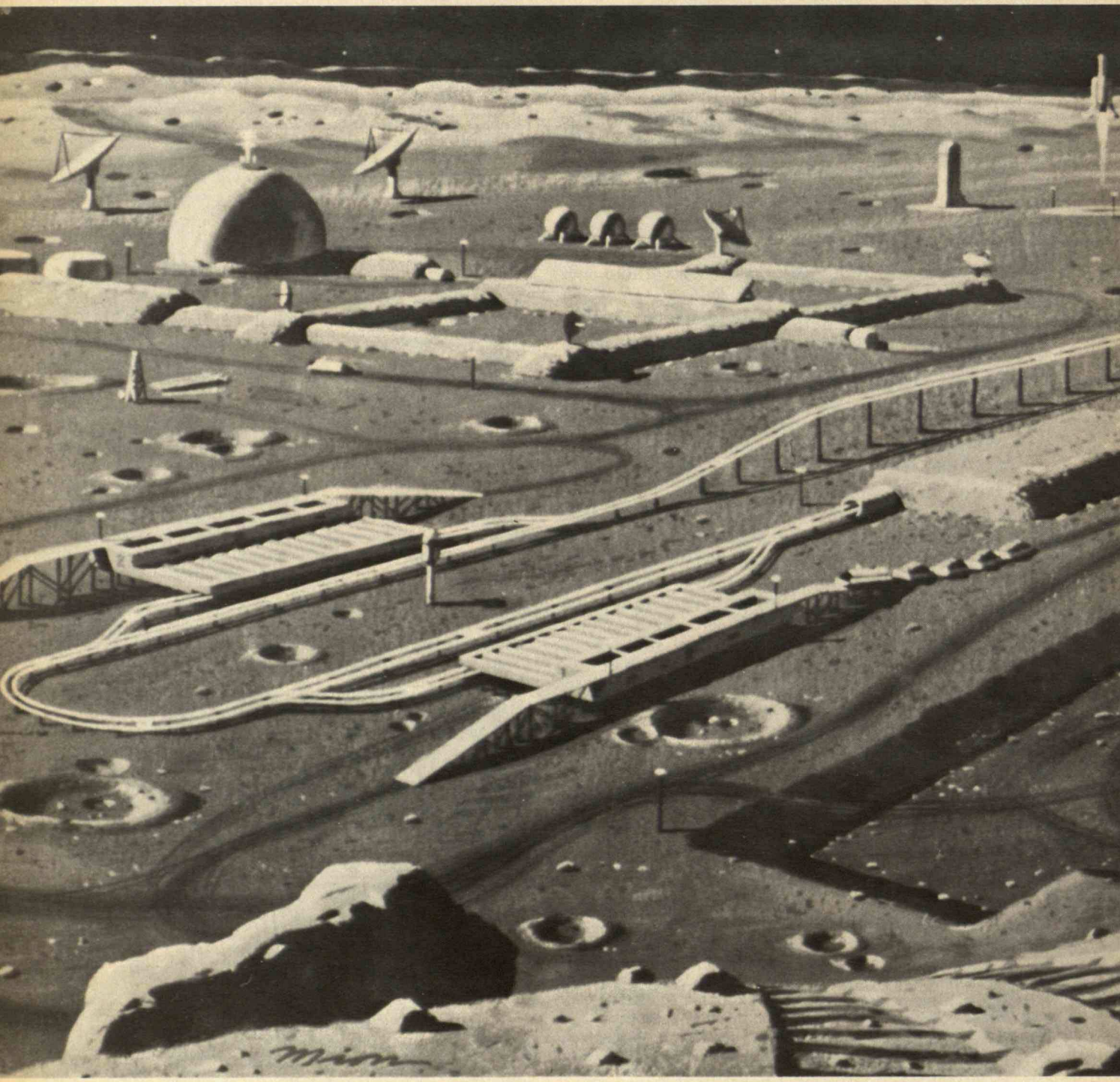
Thomas B. McCord is Associate Professor of Planetary Physics with the Department of Earth and Planetary Sciences at M.I.T. Since July, 1976 he has been on leave of absence from M.I.T. and has worked for the Institute for Astronomy, University of Hawaii, as head of the engineering and instrumentation division and the Mauna Kea 2.24-meter telescope operation and development. At M.I.T. he has been active in developing and applying remote sensing techniques, primarily reflectance spectroscopy and multi-spectral imaging, to determine the mineralogy and structure of solar system object surfaces. He founded and directed the Remote Sensing Laboratory in the Department of Earth and Planetary Sciences. The use of ground-based telescopes to remotely sense mineralogy of asteroids and other objects has led to a recent increase in efforts to develop spacecraft experiments for closer study of the moon, Mars, Galilean satellites and comets.

Michael Gaffey has recently left a staff-scientist position with the Remote Sensing Laboratory in the Department of Earth and Planetary Sciences at M.I.T. to join the Institute for Astronomy at the University of Hawaii as an astronomer. He has been instrumental in developing methods of interpreting reflectance spectra in terms of surface mineralogy. Recently his interest in utilization of space and extraterrestrial resources has involved him in several study groups and in this attempt to use newly gained knowledge of asteroid composition to solve some need for raw materials in near earth facilities development and to relieve shortages on earth.

The metal destined for earth is foamed and fabricated into a form similar to a flattened shuttlecock. This configuration provides intrinsic stability; the shuttlecock keeps its nose forward, because its center of mass is forward of the center of the figure. The glide path of such a shape can be controlled by shifting the mass internally, thus changing the center of mass. Its low density and large surface area will permit re-entry at low landing speeds and without ablation of the surface material. (Drawing: Robert Ullrich)

Harnessed sunlight could produce electricity to drive powerful electromagnetic systems to launch ore from the moon and to propel asteroids and space stations.



Henry Kolm
Francis Bitter National Magnet Laboratory
M.I.T.

An Electromagnetic "Slingshot" for Space Propulsion

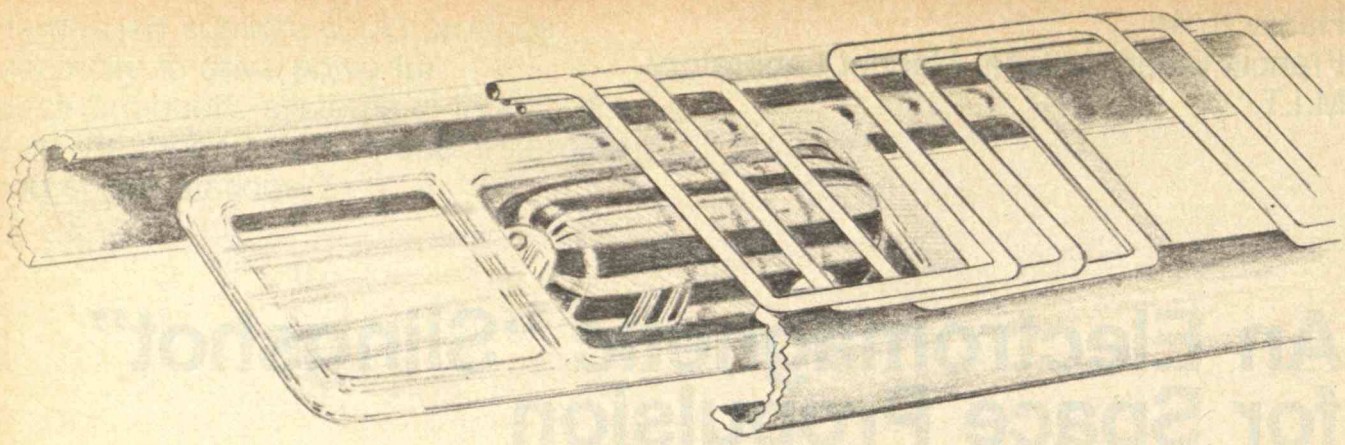
Construction in space of such massive structures as solar power plants, large exploration craft and space colonies is clearly impractical if one considers the costs and pollution involved in launching structural materials from earth using chemical rockets. As Professor McCord has indicated in an article elsewhere in this issue, the asteroids and the moon are attractive alternative sources of raw materials. For instance, soil samples from the Apollo moon landing sites average 30 per cent metals, 20 per cent silicon and 40 per cent oxygen; and at least half of this material appears usable by metallurgical processing methods. In the case of the moon, the launching of materials is facilitated by a gravitation only one-sixth that of earth and by the lack of atmosphere.

Lunar materials for space construction would provide a substantial economic advantage over earth-based materials, even if chemical rockets were used to carry them. A still greater advantage would be obtained, however, by using electromagnetic power to launch the material, for such a system could convert abundant solar energy into coherent motion by a far less circuitous mechanism than first making it into chemical fuel for a rocket. Chemical rockets would also release considerable amounts of exhaust gases, creating a highly objectionable, long-lived lunar atmosphere.

Princeton physicist Gerard K. O'Neill, widely known proponent of space colonization, first recognized the possibilities of moving masses in space via electromagnetic propulsion, and involved a number of investigators, including the author, in a project last year to design such a materials launching system for a lunar mining operation.

Electromagnetic flight has long been proposed for high-speed ground travel on earth. Wheel-less vehicles, suspended and propelled by magnetic forces along a metal guideway, could travel at speeds up to 300 miles per hour, limited only by air friction. If vehicles were run inside an evacuated tunnel, speeds would be essentially

An electromagnetic guideway could accelerate ore from a lunar mining operation, launching it to a construction site in space. The vehicle is accelerated to lunar escape velocity along the guideway, its speed monitored and corrected as it speeds down the track. At the end, the vehicle is deflected to allow the payload to continue alone on the desired trajectory. The bucket is then decelerated and returned for reloading and relaunching. Following release, the payload is monitored over several kilometers by scanners, and its course corrected by means of electrostatic deflection plates mounted on towers. (Illustration: National Geographic Society)



An electromagnetic ore "bucket," shown here speeding along a section of the electromagnetic guideway, is a hollow frame permanently filled with a charge of liquid helium. The internal superconductors create an electromagnetic force which suspends the bucket in the twin U-shaped aluminum channels which constitute the guideway. The bucket is propelled like a surfboard by a traveling magnetic wave, generated by conductors which meander back and forth across the guideway. (Only three conductors are shown; there are actually six.) The movement of the magnetic wave along the guideway is synchronized on the basis of position sensors along the guideway. (Drawings on this page and pages 63, 64, and 65, by Robert Ullrich)

unlimited. Budgetary squeezes and unproven economics, however, have kept electromagnetic flight on earth at the Wright Brothers stage.

The basic principle of electromagnetic flight is simple. It can be illustrated by holding a magnet tied to a string above a rapidly spinning aluminum disk. The magnet floats on a cushion of magnetic force, repelled by its own image created by motion-induced eddy currents in the aluminum. Lift is produced at the expense of drag, exactly as in the case of an airfoil. Electromagnetic flight is, of course, possible in the absence of air, and it differs from aerodynamic flight in two other important respects: the lift force on a magnetically suspended object becomes very high as contact is approached, and the lift-to-drag ratio improves with speed, such that less energy is expended to travel a given distance, the faster one travels.

In studying electromagnetic flight as a means of space propulsion, we concluded that electromagnetic drivers would apply to two major space operations — launching raw materials from the lunar surface and propelling large space structures or asteroids by launching waste material as reaction mass.

Launching Ore from the Moon

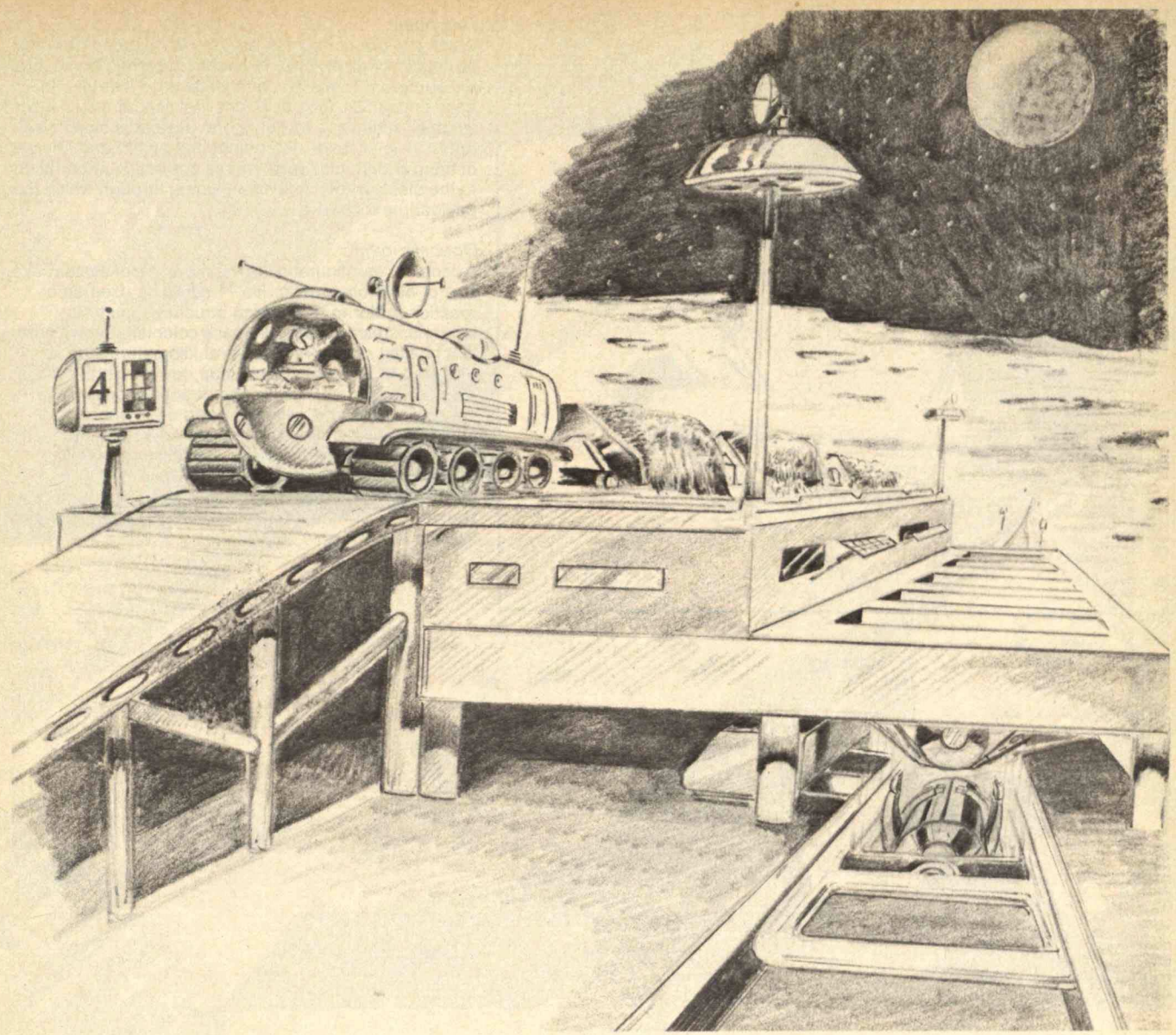
For the first purpose we designed a launching system based on the "Magneplane" electromagnetic vehicle/guideway system for high-speed ground travel, which was conceived by the author and Professor Richard Thornton of M.I.T. Magneplane consisted of a projectile-shaped passenger pod containing superconducting magnets, which were used, not only to lift the vehicle off its metal guideway, but also to propel it. The magnets served as the "rotor" part of a linear synchronous motor, riding the crest of a traveling magnetic wave, generated by coils in the guideway. These coils are actually several wires which meander back and forth underneath the guideway, energized by wayside power conditioning units, which synchronize with the vehicle on the basis of position information transmitted from the vehicle.

Our lunar mass driver differed from Magneplane, however, in that its purpose was to accelerate material down a guideway, and then accurately release it onto a predetermined trajectory.

The heart of the lunar system is a set of reusable shuttle vehicles, or "buckets," each consisting of a square tubular frame about the size and heft of a bicycle frame, and the shape shown above. The fore and aft squares of this frame contain superconducting cables at cryogenic temperatures and energized with 100,000 amperes of persistent current, so that the frame becomes in effect a permanent magnet having two large dipoles and a mass of about 20 kilograms. The frame itself is permanently filled with liquid helium at supercritical pressure, which provides enough heat reservoir for several hours of operation. The central rectangle of the square frame accommodates a 20 kilogram payload cylinder, clamped in a release mechanism. The frame is also surrounded by a thin aluminum radiation shield. The vehicle travels in a guideway as shown above, confined by two U-shaped aluminum repulsion channels and propelled by meander-shaped windings above and below. The linear synchronous motor is operated only during daylight hours using solar energy converted to direct current. Buckets are accelerated to lunar escape velocity of 2.4 kilometers per second (km./sec.) at one-half-second intervals, each bucket executing a launch-reload cycle in 100 seconds, and each being withdrawn for a ten-minute service period every two hours to have its helium reservoir recooled and its magnet current re-adjusted inductively.

Hitting a Space Target

The main challenge in designing the overall system was to achieve the accuracy required to assure that a payload would be intercepted at the intended destination, assumed to be a space station at the "Lagrange Liberation point L2," located about 63,000 km. beyond the moon. This is one of five gravitational saddle points in the earth-moon system in which a space station or space colony could be stably placed. For the extremely rigorous requirement of a one-meter dispersion at destination, the launch errors must not exceed three centimeters in vertical or horizontal launch position, 0.3 millimeters per second (mm./sec.) in horizontal launch velocity, 0.022 mm./sec. in vertical velocity, and 0.01 mm./sec. in horizontal velocity. At a launch velocity of 2.4 km./sec. such a precision seems at first glance unrealistic. Upon closer exami-



Moon ore is loaded into payload containers and placed on the high-speed ore buckets, to be launched toward a space colony.

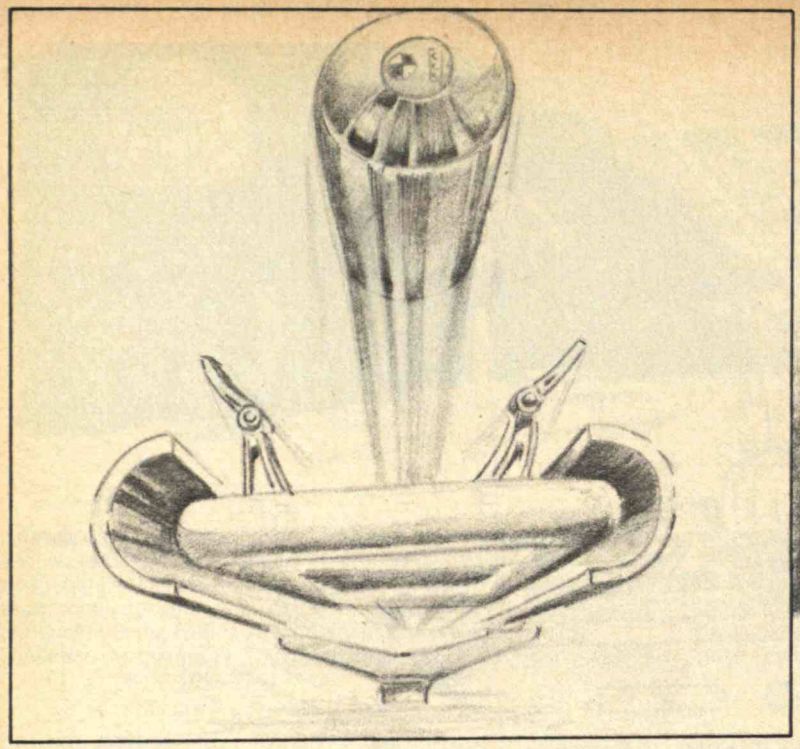
The containers, manufactured on the moon, would be consumed along with the ore at smelting plants in space.

nation of the problem, however, we found it to be quite readily achievable with available technology under even the most conservative assumptions. The overall system, illustrated on page 66, operates as follows:

The 20-kilogram bucket with its cylindrically encapsulated payload of 20 kg. mass is accelerated to lunar escape velocity (2.4 km./sec.) at 1,000 meters per second^2 (100 earth gravities) along a 2,880-meter section of guideway. The bucket is then allowed to coast, while oscillations about its trajectory are damped magnetically and its velocity is measured and corrected by impulse coils. The bucket then abruptly deflects laterally, allowing the payload to continue alone. Error could be induced by this "snapout" operation if the payload is paramagnetic, because it will be magnetically affected by the bucket. This error will be compensated for by a deflecting magnet, following which final trajectory corrections are made at several stations along a free-flight path several kilometers long. At each station the trajectory is monitored by a laser scanner which "reads" a target on the payload for speed and position information much like scanners now being introduced in grocery stores read food labels. Any course error detected is corrected by electrostatic deflection plates mounted on towers. Back at the launch point, the empty bucket is decelerated by braking, in which energy is recovered, and returned for re-loading and launching.

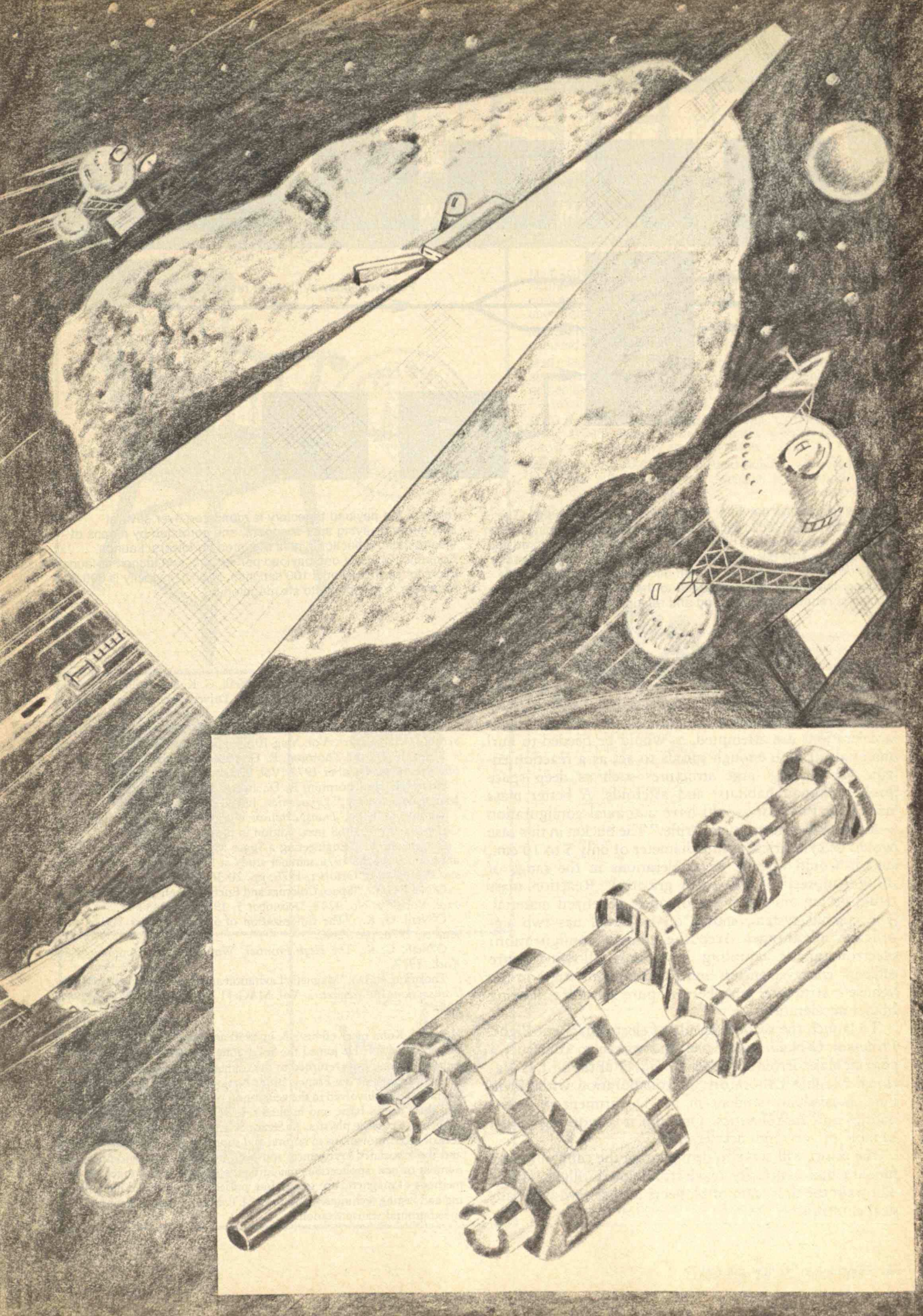
Assuming the mass driver installation, including its power plant, is transported from earth at present Shuttle payload costs, and assuming it operates at a mass launch rate of 600,000 tons/year for a ten-year amortization period, the launching cost is found to be about one dollar per kg. This is several hundred times less than the cost of earth-launch by Space Shuttle, and could make solar power plants in high geosynchronous orbit competitive with terrestrial plants. It also makes a number of other massive space operations economically feasible, and for all practical purposes makes the colonization of space as

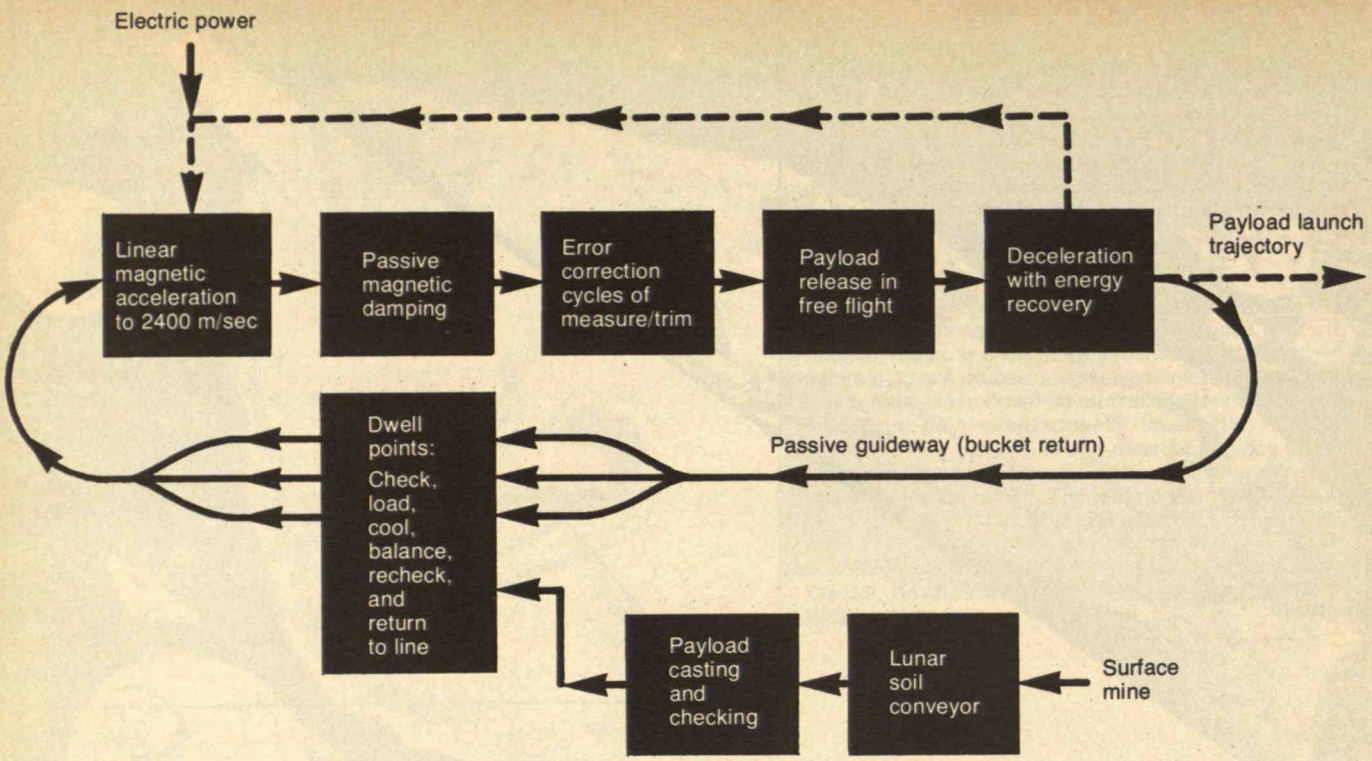
(Text continues on p. 66)



This page:
When the ore-containing payload is released from the ore bucket (upper left), its course is refined by several encounters with electrostatic deflectors (center). In each encounter, the payload is first scanned by a laser scanner aimed at a target on the payload's side (lower right). This scanner determines the speed and course of the payload and feeds course correction information to the electrostatic deflection plates, through which the payload next passes.

Opposite page:
A "coaxial" configuration of the mass driver system — a sort of electromagnetic rifle — could be used as a reaction motor to drive large structures such as asteroid, space probes, or space colonies. Shown here is a coaxial mass driver several kilometers long attached to an asteroid (closeup, lower right). It flings slugs of waste material in one direction, driving the asteroid in the other, toward earth orbit where its materials will be mined. The plate covering the mass driver is a solar power array. A working model of this device is currently under construction at M.I.T. by the author, Dr. Gerard K. O'Neill, and M.I.T. students Eric Drexler, Kevin Fine, Jonah Garbus, William Snow and William Wheaton.





A block diagram of the lunar mass driver reference design. The vehicle is accelerated to escape velocity; magnetic damping is then applied to reduce vehicle oscillations, the velocity is monitored and corrected, and the bucket is deflected so as to allow the payload to continue alone. The bucket is then decelerated by regenerative braking, the energy being returned to the feeder system, and the bucket is returned for reloading and relaunching. Following release, the payload trajectory is monitored over several kilometers by flying spot scanners, and corrected by means of electrostatic deflection plates mounted on towers. Launch frequency is about one payload per second, and launch-to-launch cycle for each bucket is 100 seconds. Launch capacity is 600,000 tons/year, expandable to six megatons.

inevitable as was colonization of the western hemisphere.

The lunar mass driver we've described is suitable for the scale in question at accelerations in the 1,000 m./sec.^{2} range. It runs into stress limitations, however, if higher accelerations are attempted, as would be needed to hurl materials at high enough speeds to act as a reaction engine for moving large structures such as deep space probes, human habitats, and asteroids. A better mass driver for this case would have a coaxial configuration —a sort of electromagnetic "rifle." The bucket in this case would be cylindrical with a diameter of only 5 to 10 cm., and it would operate at accelerations in the range of 10,000 m./sec.^{2} (1,000 earth gravities). Reaction mass could be any mining waste or other pelletized material. The coaxial system, shown on page 65, has two significant advantages over the planar configuration: electromagnetic coupling is tighter, allowing more efficient energy transfer, and the dominant stress in the vehicle's structural members is pure tension, allowing higher acceleration.

To launch the second decade of electromagnetic flight, Professor O'Neill and I have undertaken to construct a coaxial mass driver of four-inch caliber at the M.I.T. National Magnet Laboratory, in collaboration with Kevin Fine, a graduate student in the Department of Aeronautics and Astronautics. Our aim is a working model capable of very high acceleration.

The effort will serve to demonstrate the capability and fundamental simplicity of electromagnetic flight, and it will train the first team of pioneers in this new astronautical enterprise.

Suggested Readings

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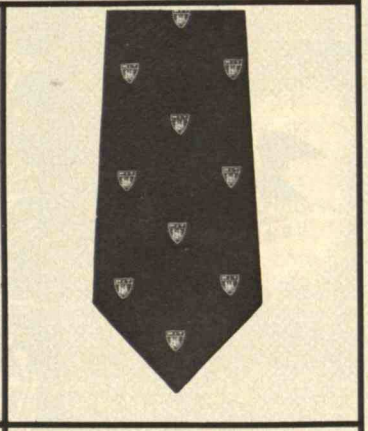
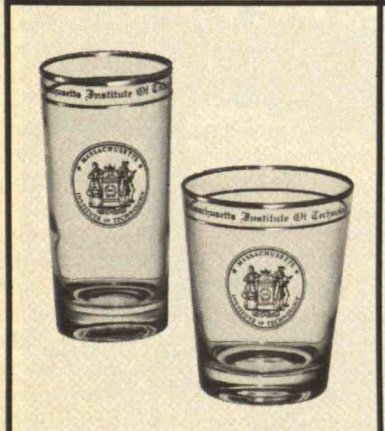
Henry H. Kolm received his S.B. in 1950 and his Ph.D. in 1954, both in physics at M.I.T. He joined the Solid State Physics Division of Lincoln Laboratory and then returned to the Cambridge campus in 1961 as one of the founders of the Francis Bitter National Magnet Laboratory. Dr. Kolm has been involved in the generation of very intense magnetic fields and their use in basic and applied research in solid state, plasma and elementary particle physics. As Senior Scientist at the Laboratory he has contributed innovations in normal and superconducting magnet systems and the associated cryogenics, and been involved in the inception of a number of new applications including the Alcator fusion machine, new methods of magnetic ore separation, pulsed magnetic field metal forming and testing techniques, and the M.I.T. Magneplane System for high-speed ground transportation.

M.I.T. INSIGNIA

A GOOD WAY TO REMEMBER





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Trend of Affairs

Trends This Month

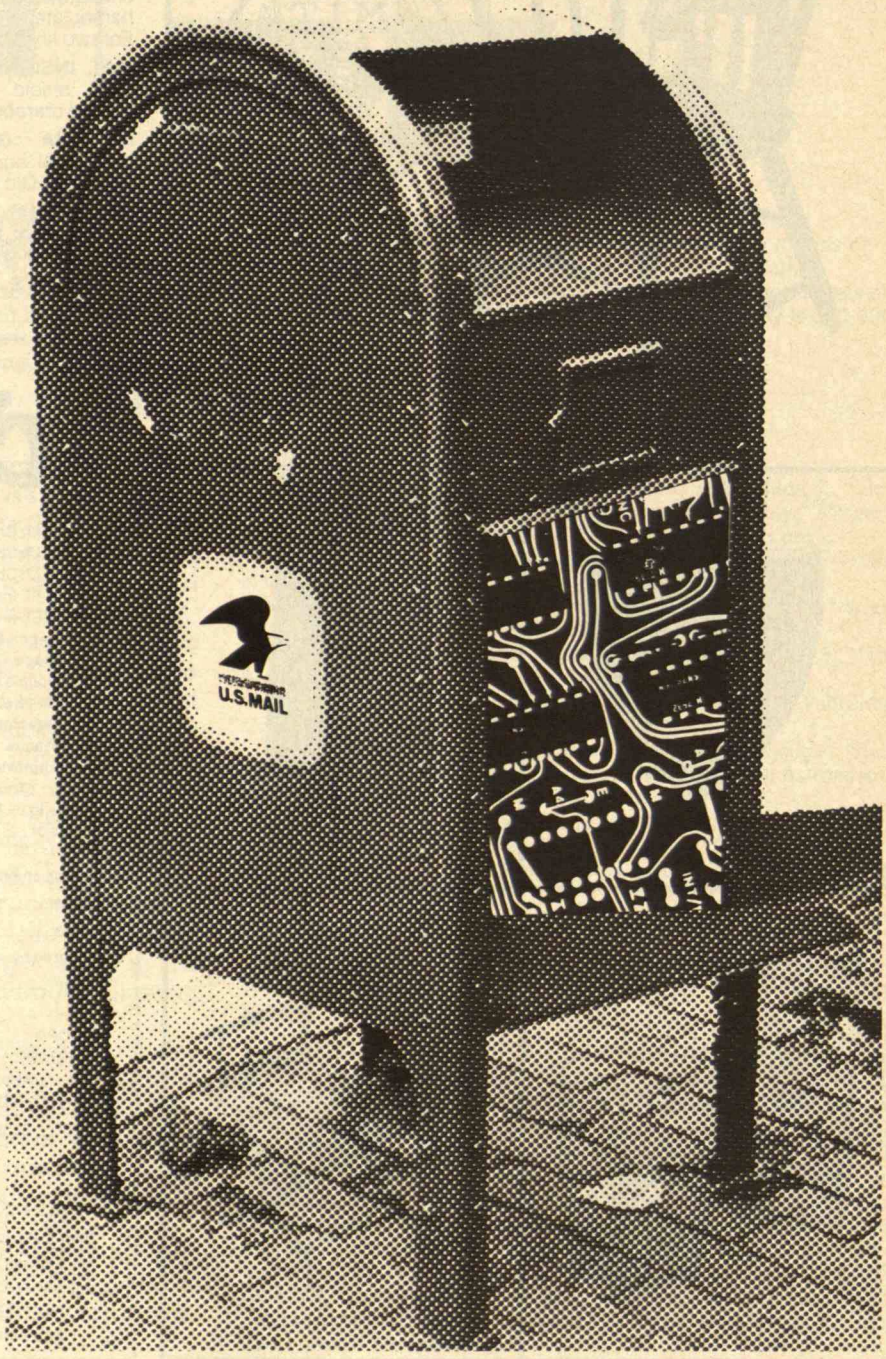


Illustration: Judy Richland

U.S. Postal Service: Electronic or Else

It's difficult to imagine the U.S. Postal Service (U.S.P.S.), with its history of deficits and inefficiencies, leading the country into a new era of electronic mail. But that is exactly what a study of the National Research Council has called upon it to do if the Service is to have a viable future.

The Council's U.S. Postal Service Support Panel released its study of the Postal Service and electronic mail last winter, declaring that "time is running out for the U.S.P.S. While it delays its entry into electronic message services, developments by private firms are sure to proceed, possibly foreclosing any opportunities for the U.S.P.S. to move into the field in any meaningful way."

The panel — 14 experts from business, industry, academia and private think-tanks — predicted that by the 1980s, electronic mail could replace as much as one-third of today's letter mail, which included nearly one-half of all first-class mail. Electronic mail's drawbacks, the study noted, include the absence of corporate logos and graphics, the inability to enclose inserts and return envelopes, and the need for security where financial transactions are involved. Thus, a considerable amount of physical mail will always exist, and mail carriers will be braving rain, snow, and sleet even into the distant future.

The panel defined three generations of electronic mail through which the U.S.P.S. could evolve, perhaps in cooperation with private industry.

Generation I is an extension of the current first-class mail stream, with all mail handled physically, except for selected links between post offices. Generation II calls for electronic input and transmission of information, with hard copy produced at the destination post office and delivered by letter carrier. The Mailgram, already in wide use, is an example of a Generation II system. Generation III would be an entirely electronic system, in which information would flow from sender to recipient in purely electronic form, and hard copy would be produced only if the recipient required it.

Technology is not the limiting factor in electronic mail, concluded the panel. Equipment to handle electronic mail is already available or in development. Nevertheless, modification and equipment development will be necessary to arrive at an effective electronic mail system.

The economics of electronic mail are still doubtful, said the panel, especially for a Generation III system. "The average household receives only around ten pieces of mail per week, of which about six are first-class pieces. . . . This relatively small amount makes it quite improbable that the average household will install a terminal solely for the receipt of electronic messages."

Although the U.S.P.S. may not own and operate the entire system, and will lease parts of it from private companies, it will have to manage the entire system for maximum effectiveness, concluded the panel.

There's the rub. Developing and managing an enormous and complex electronic mail system will mean that the U.S.P.S. "will have to come to grips with very difficult and sophisticated decisions —ones that are enormously different from those it has been accustomed to facing." Such developments will also require far more research and development than has been done by the U.S.P.S. in the past.

The panel conceded that many of the decisions about the U.S.P.S. and electronic mail will be made in the political arena, and private enterprise is certain to voice strong objections to totally government-controlled electronic message systems.

A recent study of electronic funds transfer systems by Quantum Research Corp., a research firm, asserted that "Congress must be dissuaded from enacting protectionistic U.S. Postal Service legislation which would impede electronic mail growth. Both [Postal Service] and electronic systems should be allowed to seek their own independent levels." The Quantum study concluded that the Postal Service, in the end, will have little voice in electronic mail, and will probably lease its network from private enterprise.

Private enterprise probably has little to worry about regarding competition from the U.S.P.S., if the past record is any indication. In commenting on previous studies of electronic mail for the U.S.P.S. which called for electronic mail, the N.R.C. panel commented that it was "somewhat surprised that the previous studies had made so little impact on U.S.P.S." —*D.M.*

A Revolution in Information

Vannevar Bush called it "Memex" — a writing, reading, filing, and communication system with screen and keyboard, all contained in a desk-like cabinet. That was in 1945, and for many readers Dr. Bush's vision in "As We May Think" (*Atlantic Monthly*, July, 1945) must have seemed more fiction than prediction.

More than 30 years later "Memex" is still just a vision, and the information revolution it represented is "the last remaining unfinished business of the industrial revolution," says John C. R. Licklider, who now teaches communication science in the same M.I.T. classrooms Vannevar Bush used before he was called to Washington in 1941. But we are now poised on the brink, with technology moving us inexorably and very rapidly into a world which might astonish even Dr. Bush.

Among the critical elements which will soon be fundamental components of this information revolution:

— The rapid advance of computers-on-a-chip technology, their capacity increased by 10,000 times since 1960, the cost down to $10 per chip and falling. Dr. Licklider, speaking to members of the American Association for the Advancement of Science in Denver last winter, was confident of continued advances — a factor of 1,000

more in capacity and further decreases in cost.

— The development of a "TV disc" containing thousands of memory bits as accessible as the notes of a great symphony.

— The achievement of computers that can draw pictures that are "very nearly" real. This crucial step in the information revolution, will end our reliance on charts and graphs which are foreclosed to readers who cannot easily deal with such abstractions.

— The spread of digitalization. The whole communications process will soon be conducted digitally; in 50 years even ordinary telephone conversations will be moved in digital pulses, and this in turn will make possible the true integration of communication and computation in a single technology.

— The mastery of speech by computers —the ability automatically to translate information between aural (spoken), digital (storable, communicable), and alphanumeric (readable) forms.

Pocket calculators are among the first ubiquitous fruits of the new solid-state technology, achieving the highest mass penetration yet of any information revolution technology. What cost $170 in 1974 now costs only $25, and L. J. Donohoe of Texas Instruments, Inc. says that there is no limit yet in sight. Technology will add "more and more capability to hand-held calculators at lower and lower prices for years to come," he told the A.A.A.S.

Another precursor is E.I.E.S., the Electronic Information Exchange System being developed by Professor Murray Turoff and his colleagues at the New Jersey Institute of Technology. It's a computer-based information storage and editing concept for connecting up to 300 users. This "community blackboard" can perform such tasks as sending messages to colleagues, editing reports with colleagues' help, publishing professional papers, arranging and holding conferences and acting as a "total communication environment" for a dispersed group of scientists with common interests. Dr. Turoff told the A.A.A.S., that E.I.E.S. is the prototype of a single system which will eventually embrace abstract services, journal and book publication, word processing, computerized conferences, and information retrieval systems. That system would completely change publication techniques and processes, and it would "revolutionize peer group communications," he said. — *J.M.*

Computing Benefits of Computing Systems

How can a computer-shy public be brought to accept with confidence a growing role for computers in their daily lives?

Let them understand, in very concrete terms, the risks and the benefits at stake, says Ruth M. Davis, Director of the Institute for Computer Sciences and Technology at the National Bureau of Standards.

Dr. Davis is convinced that much public mistrust of computers today results from the "festering ineptness" of computer professionals' responses to legitimate questions about performance, privacy, and cost of computer applications. To quantify such problems, and to help the public set standards and make decisions, Dr. Davis proposes a risk/benefit formulation of data processing issues.

Looking at the problem in this way will help isolate points of danger, evaluate possible responses, and evaluate their cost. It will clarify the principle that "a computer system is safe if the probability of loss or damage due to undesirable events or adverse effects is judged to be acceptable," she told the A.A.A.S. last winter.

Consider a fictionalized example which might arise in evaluating computer processing of school records. It may be determined that lack of control over inputs to the system results in a 5-per-cent probability of loss of scholarship opportunity by students, with a potential loss being $30,000 of educational benefits to a wronged individual.

But against this potential loss must be balanced the risk and cost of error in the older, noncomputerized school record system, and also the cost of changing the computer-based system to reduce the risk of error.

Only with this kind of analysis, said Dr. Davis, can there be real public understanding of problems and alternatives as the computer continues its advance into our lives. — *J.M.*

UNDERWATER

Another Go at Loch Ness

This month a team of divers, equipped with two-way radios and with television cameras attached to their helmets, will descend into the dark waters of Scotland's Loch Ness, once more trying to solve the tantalizing mystery of the legendary Loch Ness monster. They will be investigating the neolithic stone rings discovered during last year's sonar scan of the loch bottom, and will also attempt to identify the mysterious submerged objects which experts believe have at least an outside chance of being the remains of one of the controversial beasts.

The divers are engineers and archaeologists from Underwater Instruments (a British firm) and from the University of Strathclyde in Scotland. The expedition is sponsored by the Boston-based Academy of Applied Sciences, which last year discovered the underwater objects and which, two summers ago, captured on film what seems to be the beast. (*See March/April and December, 1976*).

The expedition again will be led by Robert Rines, a lawyer-engineer who is president of the Academy. Photographic experts aiding him include Harold "Doc" Edgerton of M.I.T., Charles Wyckoff of Applied Photo Sciences, Inc., and John Lothrop of Polaroid Corp.

The divers' television-equipped helmets will enable observers on the surface to share in any underwater encounters, and their two-way radios will help the rowboat kibbitzers direct the action. The divers' explorations will be videotaped for archaeologists and other scientists interested in the Loch Ness phenomena to review.

Efforts to photograph the beasts which supposedly inhabit the loch will be redoubled by the addition of camera forays into previously unstudied areas of the loch. Until this year, almost all the underwater exploration had been done in Urquhart Bay, where the animals are believed to hunt the salmon which swim into the bay and up its tributary rivers to spawn.

Besides the stationary camera strobelight system suspended from an anchored raft used last year, the new 1977 expedition includes several underwater portable cameras. Each portable unit will contain a 35-mm. camera capable of taking 250 pictures, a powerful strobe-light, and a computerized sonar triggering device to "watch" the area in front of the camera and automatically start the camera should a large object intrude.

Each camera strobe system will be mounted on a special metal frame designed to solve one problem which has nagged past underwater photographic efforts — the attenuation of light in the brown, particle-filled waters of the loch.

Rather than attaching the strobe light near the camera, the light will be mounted at the end of a long boom, extended out over the camera's field of view. Thus, strobe flashes will not have to make the two-way trip out to the photographic subject and back to the camera. With this new arrangement, the scientists are confident that they can achieve good pictures of objects even 25 ft. from the camera.

The Loch Ness beasties, or their absence, will no doubt continue to spark feuds in the scientific world. Skeptics still declare the beasts to be no more than creatures of overly fertile imaginations, while believers cite evidence which they say can be explained logically only by the existence of a population of large creatures living beneath the waters. So this year as last, purely to allow cool and impartial journalistic judgement of the expedition, this writer will accompany the scientists. — *D.M.*

(Dennis Meredith, Managing Editor of Technology Review, *is the author of* Search at Loch Ness *(Quadrangle/*New York Times *Book Co., 1977). He was allowed to accompany this year's expedition [at his own expense] only if he promised not to force his colleagues to view his slides.)*

Raise the *Monitor*!

The "cheesebox on a raft" was a remarkable ship. With only two guns, the Union's ironclad *Monitor* terrorized the Confederacy's wooden vessels and, in one of the most famous sea battles in history, defeated the larger ironclad *Merrimac.* Considering her tremendous significance in naval history, the *Monitor*'s end was especially anticlimactic, for one stormy night in December, 1862, this prototype of the modern battleship sank while being towed off Cape Hatteras.

The various goings-on since the *Monitor*'s discovery in 1973 (*see February, 1975, pages 8-9 ff.*) have proven just as exciting and controversial as was the *Monitor* in her heyday. According to Robert E. Sheridan, marine geologist with the University of Delaware, it could be quite feasible to raise and restore the *Monitor* intact.

In January, 1975, the *Monitor* wreck site was established as the U.S.'s first Marine Sanctuary, administered by the National Oceanic and Atmospheric Administration with advice from numerous interested governmental agencies. Access to the site was carefully regulated so that future work on the wreck could be controlled.

"Thus far, these governmental agencies have assumed a passive, sometimes even negative role, as protectors of such an important national cultural resource," noted Dr. Sheridan. "Because of their responsibilities as referees, they have, I believe, prevented themselves from becoming players in the game. As a result, no government agency has put forward a positive plan for the future of the *Monitor.*"

Dr. Sheridan, marine scientist John Newton, and M.I.T. Professor Harold "Doc" Edgerton proposed to continue studies of the wreck in 1975, but found themselves just as mired in governmental bureaucratic wrangling as was their quarry in the sands beneath the waters off North Carolina.

"They could not approve our plans because they did not see how they fit into a long-range plan for the *Monitor,* but since no government agency had yet developed such a long-range plan, we were trapped in a *Catch-22* situation," said Dr. Sheridan.

To strengthen their hand, the *Monitor* afficionados, including specialists in history, archaeology, oceanography, and engineering, banded together into the Monitor Research and Recovery Foundation, founded in 1975 and headed by Dr. Sheridan. The foundation proposes a six-phased effort to raise the *Monitor* intact from 220 feet of water.

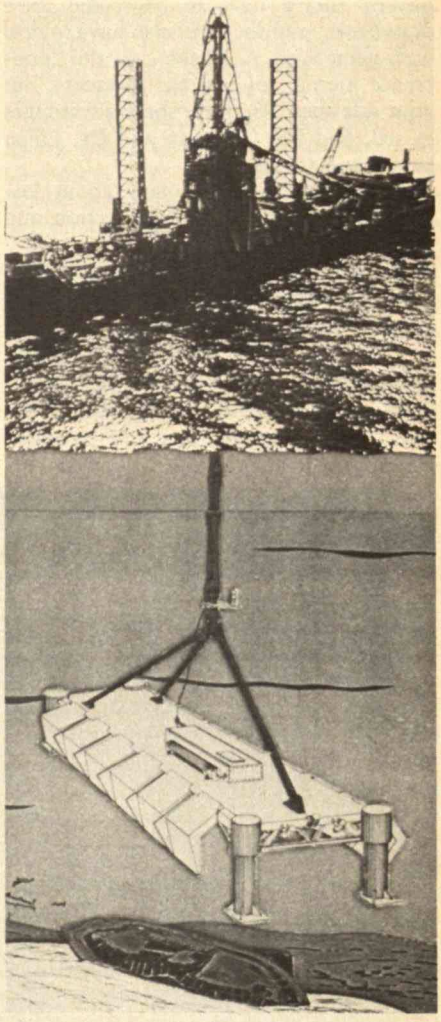
Phase I, the discovery and identification stage, has already been completed. Phase II will consist of careful study of the wreck using magnetometers to determine where the various parts landed. The scientists want to know particularly where the huge 40,000-pound guns lie, and the nature of sediments underlying the wreck. Phase II is proceeding this summer.

Phase III will involve site-testing of the wreck for structural integrity and the extent of corrosion. Preliminary results from magnetometer readings and examination of a deck-light cover recovered from an area well clear of the wreck indicate that only moderate corrosion has taken place. The structure was apparently well sealed by encrustation with sea life. The orientation of the wreck also gives some clue as to its strength. The wreck is held up at one end by the turret, for it apparently capsized after sinking and came to rest upside down. Also, the outside armor belt extends for some 140 feet without support. Both these features indicate that there is considerable structural strength in the wreck, and raise hopes for its intact recovery.

Phase IV, the wreck's recovery, will certainly be the most exciting. "One alternative might be the lifting of the wreck intact for transfer to shallow water," said Dr. Sheridan. "In shallow water it could be studied with convenience during preservation operations, Phase V. Tourists in glass-bottom boats might view the progress of this phase, Dr. Sheridan suggested. Finally, in Phase VI, the *Monitor* would be reconstructed and displayed in a museum developed around it.

One recovery plan has been proposed to the Foundation by the Global Marine Development Corp.: the sophisticated lifting vessel, *Glomar Explorer,* could be used to lower a box-like undersea recovery vehicle to completely surround the *Monitor.* The vehicle would possess bomb-bay-type doors which would bite into the sediment on either side of the wreck, closing to lift the wreck and some 30 feet of underlying sediment into the vehicle. Then 5 million pounds of sea floor sediment and the 1.5-million-pound *Monitor* would be hoisted into the Explorer's center-well, to be transported to shallow water, where it would be deposited with the vehicle still surrounding it for protection. By keeping the *Monitor* under water the entire time, the scientists hope to minimize further corrosion of the vessel.

If this technique sounds like something out of a James Bond thriller, it should. It's basically the same method used by the *Explorer* to secretly recover a sunken Russian submarine for the C.I.A. in 1975. — *D.M.*



One plan to raise the Civil War ironclad *Monitor* involves using the *Glomar Explorer* to lower a large undersea recovery vehicle over the top of the warship. The doors of the vehicle would clamp shut, digging 30 feet into the sediment beneath the *Monitor,* and the ship would be hoisted intact into the Explorer's hold, to be transported to shallow water for restoration. (Photo: Robert Sheridan)

Innovation: The Blind Man's Elephant

Different people weigh the advantages and disadvantages of a new innovation according to their own perceptions. Jean-Marie Choffray and Gary R. Lilien of M.I.T.'s Sloan School conclude in a recently released study that innovators ought to be able to capitalize on these differences in both product design and marketing strategies. They hypothesize this scenario:

You've developed and are ready to market a new, solar-powered industrial air conditioning system. It has a low operating cost; protects against fuel shortages, outages, and price increases; it's quiet; reduces pollution; and it's "modern." But the first costs are high, and it depends on unconventional technologies, seen by potential customers to threaten reliability.

When your salespeople call on potential buyers, they'll have to overcome these drawbacks, and they will also have to deal with what Scott A. Neslin calls the "preference inertia" of familiar products. But your salesmen also have some advantages to sell, and Dr. Choffray and Dr. Lilien have some advice:

— Tell production engineers about low operating cost, fuel supply protection, and the "modernness" idea.

— Tell top management about the advantages, but expect trouble with questions of reliability and high first cost.

— Emphasize to the plant's air conditioning consultants their immediate concerns: initial cost, noise level, and reliability. Operating cost, fuel supply protection, and "image" won't count for so much.

— Relax with the production engineers: they are likely "to favor the equipment which makes their job more challenging," say Dr. Choffray and Dr. Lilien.

The analysis of potential customers' responses to the yet-to-be-commercialized air conditioning system comes from a series of questionnaires completed by officials in various positions in a sample of firms selected to represent many sizes, locations, and industries, and in a number of firms specializing in air conditioning design and installation.

For example, the single most important marketing impediment to the solar-powered air conditioning system (aside from price) was uncertain reliability, an especially strong concern among consultants. An innovator's engineering and marketing groups could both benefit from that kind of information, say Dr. Choffray and Professor Lilien.

What role does the simple fact of "newness" have to play in the acceptance of such an innovation? Some people are attracted to a new product because of its newness, others turn away from it as untested; the latter response was clearly a factor in the consultants' perception of the solar-powered air conditioner.

By studying the reactions of the M.I.T. community to three innovative new health care plans which were offered two years ago in place of the conventional medical coverage, Mr. Neslin has contributed to the meagre knowledge of what he calls "preference inertia" — the tendency of people to stick with familiar products despite the advantages of new ones.

The healthier, younger, unmarried males in the M.I.T. community were distinctly more receptive to the innovative health care plans (showing less "preference inertia," in other words). Those who had relied most heavily on conventional medical plans were most resistant to change. — *J.M.*

	Issues of key importance	Issues of less importance
Production engineer	Modernness Protection against fuel shortages Complexity	First cost
Corporate engineer	Reliability First Cost	Modernness Energy savings
Plant Manager	Protection against fuel shortages Modernness Low operating cost	First cost
Top manager	Protection against fuel shortages Modernness Low operating cost	Noise level Ease of maintenance
Air conditioning consultant	Noise level First cost Reliability	Modernness Low operating cost

On the basis of how different officers evaluate the advantages and disadvantages of a hypothetical solar-powered industrial air conditioning system, some advice to would-be marketers of innovations from Jean-Marie Choffray and Gary L. Lilien of M.I.T.'s Sloan School of Management: form "microsegments" of your potential markets and study separate strategies for making your new product more acceptable to each.

Rent Burdens Rise

The cost of housing is rising so much faster than the cost of almost everything else that "housing deprivation" is spreading from low-income to middle-income families in the U.S. New homes are now out of reach for families whose annual income is less than $20,000, and homeowners' costs have advanced so rapidly that nearly 17 million U.S. households are paying more than they can afford for the housing they have.

Most U.S. families know all this from hard, personal experience, but now it's official, documented in a major research project by Bernard J. Frieden and Arthur P. Solomon of the Joint Center for Urban Studies of Harvard and M.I.T.

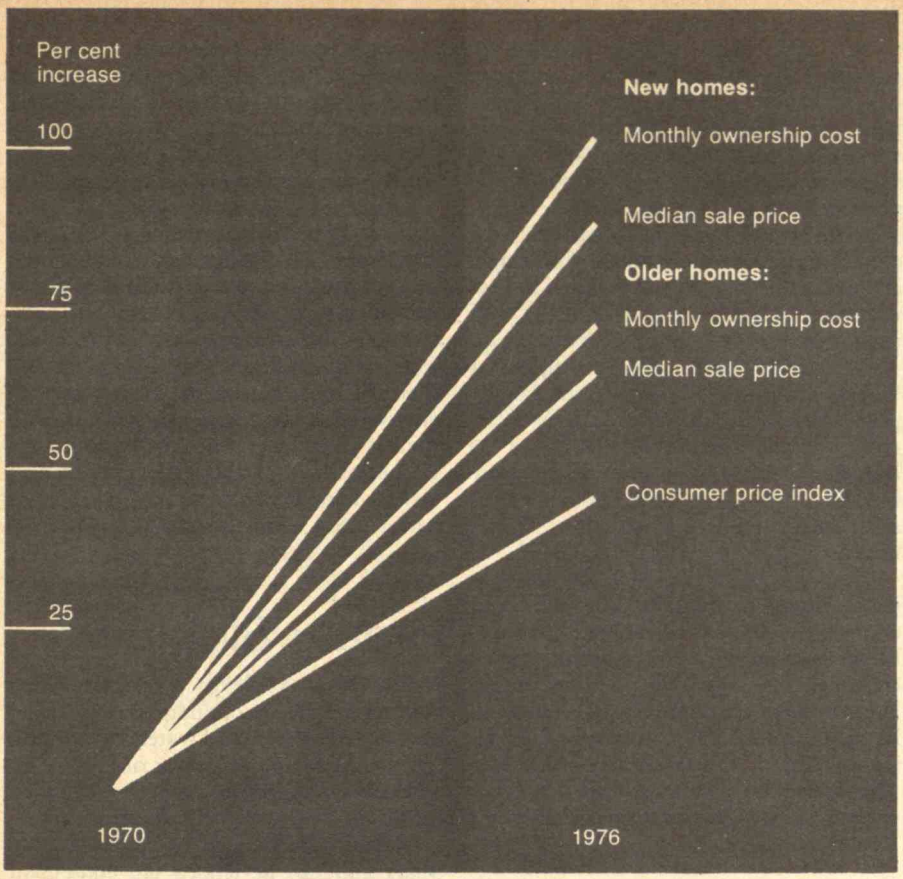
The J.C.U.S. has been following U.S. housing trends and needs for over 20 years. In that period, the number of low-income families living in physically inadequate housing units has declined. But the number paying an unreasonably high percentage of their income for housing increased dramatically.

In the same period, the cost of new housing has advanced significantly, so that as of 1975 only 25 per cent of all U.S. families could afford to buy a medium-priced new home. Only a few years ago, in 1970, half of all families could afford such a standard home.

If inflation in new construction costs continues, the selling price of such an average new home could reach $78,000 by the early 1980s. Only the most affluent groups would then be able to afford one, says the J.C.U.S. study. But 20 to 22 million new housing units will be needed in the next decade. Half of them will shelter new households resulting from the baby boom in the 1940s and 1950s. And, there's a long-term trend in the U.S. toward ever-higher rates of household formation; that is, Americans are tending to split up into smaller and more numerous living (and hence housing) units.

"The shrinking purchasing power of the home buyer is not yet a crisis," says Dr. Frieden, but he and Dr. Solomon conclude that "the U.S. has seriously fallen behind in meeting the housing needs of the American people."

They want "a strong national housing policy" which focuses on "better, more af-



While inflation has added a little less than 50 per cent to the prices of most things since 1970, the cost of owning a house has advanced by nearly 75 per cent and the cost of buying a new house by nearly 90 per cent in the same six-year period. That's why "housing deprivation," which has traditionally been a problem only among America's poor, is now an issue for many middle-income families and may affect as much as 24 per cent of the total population. The figures are from a new study by the Joint Center for Urban Studies of Harvard and M.I.T.

fordable housing for the poor, with secondary emphasis on improving the home-buying climate for the young and for people with average incomes." Additional income for the poor, to reduce their "housing deprivation," new homebuilding technology, and subsidies would be important elements in such a new policy. — *J.M.*

PEOPLE AND FOOD

A Metronome for the Rhythm Method

An instrument that allows a woman to decipher her own body's signs of fertility has been developed by three Cambridge researchers. It's a technologically sophisticated variation of the old-fashioned rhythm method, and, say the researchers, can be more effective than the pill when used properly.

The rhythm method of family planning has always had a dismal record. About 35 per cent of the women who try to avoid pregnancy by this means fail. The time between the end of menstruation and the beginning of ovulation varies and eludes accurate estimation. Other methods of birth control, such as pills and intrauterine devices, are 90 to 95 per cent successful, but their side effects and physical complications are prevalent and discouraging. In addition, the Catholic Church has denounced artificial means of preventing pregnancy, leaving Catholic women with few options and more children.

Pregnancy can occur only during the three to six days when the egg, released from the ovary, travels to the uterus. Most popular family planning methods involve mechanical barriers to sperm, intrauterine devices, or chemical manipulation using hormones to interfere with this cycle.

The new process — using an instrument its inventors call the "ovutimer" — makes possible accurate prediction of ovulation time. The ovutimer, or viscometer in its clinical version, measures the viscosity of the cervical fluid. Cervical fluid alters in a drastic and easily measured way during ovulation.

The three researchers — Louis Kopito of M.I.T., Dr. Harold Kosasky, gynecologist with the Harvard Medical School, and Dr. Samuel Schuster, surgeon with Boston Childrens' Hospital —discovered that cervical mucus, and other body fluids, react to the increased secretion of estrogen that reaches its peak at ovulation. During ovulation, the mucus becomes thin, watery, and abundant, and provides an easy passage for sperm. During the rest of the cycle, the thick, sticky mucus is an effective barrier to sperm and other intruding organisms.

The mucus begins to thin three to four days before ovulation as estrogen levels rise, and thickens again in the day immediately following ovulation. The ovutimer will allow a woman to test her self daily, taking a sample of cervical fluid and placing it between two small, plastic plates engraved with microscopic grooves. The two plates either stick together under light force or they don't, providing a "go or no-go" indication of fertility on that day.

The viscometer was described at a scientific meeting last spring, and within 48 hours the researchers were contacted by the Natural Family Planning Federation, a research organization funded by the Knights of Columbus. Their findings were rushed to Rome, where the method received immediate papal approval.

Over a dozen viscometers are now being tested in clinics in the U.S. and elsewhere. The consumer version of the device will most likely be on the market within the year, say the researchers. Its cost will be competitive with other methods of birth control — about $10 for the syringe-like sampler and about $.25 for each set of disposable plastic testing plates.

Dr. Kopito, a Senior Research Scientist in the Department of Nutrition and Food Science, was formerly an associate with the Boston Childrens' Hospital and Harvard Medical School Department of Pediatrics. His experience working in an abortion clinic there taught him the need for a "morally acceptable, non-hormonal, non-interfering, non-continuous" means of birth planning. And, he adds, "We can help solve the world's food problems best by keeping population down."

Viscosity variations in cervical mucus were first discovered by cattle breeders in the 1930s. In the last 40 years, attempts have been made to use this discovery to detect ovulation time, but these required complicated laboratory procedures and could not be applied to individual cases. Dr. Kopito's training in engineering analysis yielded his redefinition of cervical mucus as not one, but three chemically and physically different fluids, which are easily differentiated by their degree of viscocity.

The doctor's version of the device, the viscometer, measures mucus stickiness precisely enough to allow many women who had previously been unable to conceive because of erratic or short ovulation periods to predict their cycles of fertility. — *S.J.N.*

Rice grown in China's rainy southeast is still planted and weeded by hand. Labor intensive agriculture is the key to their productivity. (Photo: Jack R. Harlan)

The Thrifty Peasant Makes Do

Labor-intensive agriculture is the key to China's ability to feed her 850 million people on only 107 million hectares of arable land, Jack R. Harlan, University of Illinois agronomist, told the American Association for the Advancement of Science in Denver this winter. The Chinese are applying the knowledge accrued from thousands of years of agricultural parsimony, and in some cases have achieved what looks like perpetual biological motion — everything eats something else.

In one complex food producing cycle in China's rainy southeast where the low-lying land must be drained, the drainage ponds are stocked with grass carp, an edible fish. In the areas fringing the ponds, the farmers grow sugar cane, and regularly strip the lower leaves from the cane stalks to feed the fish. On the ridges of higher ground separating the ponds, silkworms feed on rows of mulberry bushes. Each fall the bushes are cut to the ground to make room for a quick crop of cabbage. To complete the cycle, the commune members build their privys over the fishponds, and the nutrients return to the ground.

Such farming requires thousands of working hands for success. Dr. Harlan saw one commune produce three crops from the same field. About a month before the winter barley crop is ready to harvest, fledgling cotton plants are wedged between the rows of barley. While the cotton yields are slightly lower because of their early competition with barley, the cotton ripens in time for the transplant of rice seedlings to the field at the onset of summer. To prevent infestation by insects, each seedling is carefully examined for egg clusters before transplanting — a very labor-intensive task. Thirty-day crops, such as onions and carrots, are yanked from the ground by hand before the insects have a chance to attack them.

Chinese agriculturists let nothing go to waste. High-yield Texas sorghum is grafted to the stalks of the tall, woody native sorghum, and the crop is used for both food and as a wood substitute. Ponds are stocked with ducks. The ducks eat the weeds, and the people eat the ducks. To stop weeds from clogging shallow irrigation ditches, farmers build trellises over the canals and grow soybeans. This single extra step discourages weeds, makes maximum use of land and sunlight, and yields a needed increment of food.

Dr. Harlan gave other examples of "social ecology." China has the largest population of pigs in the world. The 250 million pigs function as food and as biological recyclers, as they are fed only inedible scraps and wastes. Human wastes are regularly collected and used as fertilizer.

China has no central plan for optimizing her land production. The import of non-indigenous biological pest controls has been minimal, as has been the use of chemical pesticides. The "scientific effort" in China involves relatively little research, R. James Cook of the University of Washington added. Emphasis is on the late Chairman Mao's admonition to "do what you can with what you've got." — *S.J.N.*

ENVIRONMENT

20 Argo Merchants In Six Months

In six months between January and June, 1942, at least 30 loaded tankers were sunk by German submarines within 50 miles of the U.S. East Coast. They carried 145 million gallons of petroleum products, some of which was burned but most of which must have been released into the Atlantic. It was the equivalent of at least 20 sinkings — almost one a week — of the Argo Merchant, which released 6 million gallons of oil into the Atlantic 20 miles off Nantucket last winter.

What happened to all that oil spilled into the Atlantic 35 years ago? And what ecological damage did it wreak, and where?

Intrigued by those questions and the light their answers might shed on current concerns, Bradley Campbell, Edward C. Kern, and Dean A. Horn of the M.I.T. Department of Ocean Engineering have studied the U.S. Hydrographic Wreck List, Fifth Naval District oil slick records, wind and weather histories, and local East Coast newspapers.

Their answers: most of the oil floated out to sea; pre-war baseline information is so sketchy that no one can be sure about ecological impact.

The M.I.T. engineers have fair confidence in their answer to the first question. There are countless reports of offshore oil slicks in the spring of 1942. But results from a computer simulation based on weather and sea conditions known to have prevailed at the time are confirmed by local accounts: most of those slicks moved northeastward, out to sea; few beaches were fouled, and only a few of the many casualties' bodies came ashore.

Evidence on environmental damage is sketchy and circumstantial. Old-timers remember that fishing was good off the coast throughout the war. Oiled birds on the beaches are recorded in local accounts, but no estimates are possible of overall effects on populations. "Findings indicate that the ecology of the coastal regions survived this wartime devastation, though there is no definite evidence that long-term or permanent damage did not occur," writes Mr. Horn, who is Director of M.I.T.'s Sea Grant Program. — *J.M.*

Greasy Slick Stuff

When the tanker *Argo Merchant* spilled millions of gallons of pudding-thick boiler fuel into New England waters last winter, Jerome Milgram, Professor of Ocean Engineering, arrived on the scene to take a gallon of oil back to his lab at M.I.T.

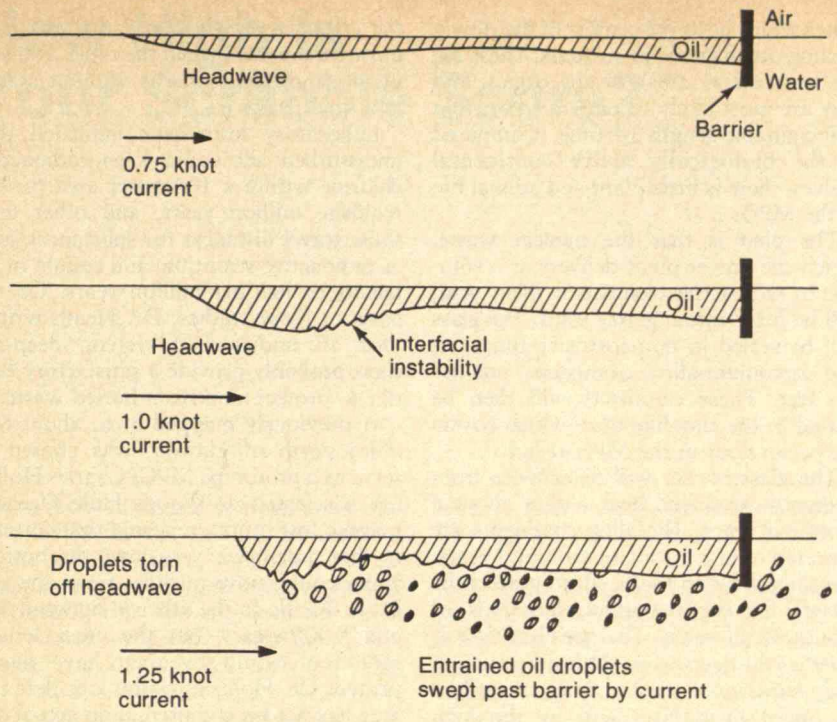
He has been studying oil spills for seven years and has developed lab equipment — a channel where computer-controlled breaking waves form at precise intervals and locations; a flume where a facsimile of oil droplets churn through rushing water — which allows him to see many aspects of the oil's interaction with the sea.

His analysis: the oil from the *Argo Merchant* was not heavy enough to sink and remain on the bottom, unless it was mixed with a sinking agent such as sand. (Oil on the bottom may mean a temporary ban on some fishing, including shellfish; on the top, birds suffer; dispersed throughout the water, oil enters the food chain.)

There are clean-up methods, although they are fraught with problems.

A thin slick can be concentrated by dragging through it a floating barrier which extends above and below the surface. But oil can leak past the barrier. Independent of barrier design, one problem appears fundamental to the concept of oil containment. According to Robert J. Van Houten, research associate at M.I.T., a lump or headwave forms at the leading edge of the oil pool thickened by the barrier. At speeds of one knot, oil droplets tear from the lee side of this headwave. Depending on their size and make-up, the drops either rise to the slick or flow beneath the barrier. The rising droplets are slow to rejoin the slick, so many of them are swept under the barrier. "The extent of this entrainment of oil increases with towing velocity, and it is virtually impossible to collect most of an offshore oil spill at speeds greater than one knot," says Dr. Van Houten.

Professor Milgram says that a computer analysis of the shape of the wave formed



A thin oil slick can be concentrated by dragging a barrier through it. But as current speeds increase, an unstable headwave forms.

Droplets of oil are torn from the headwave and swept past the barrier.

in the oil within the barrier can help. Thus he can determine the velocity of the water at every point in the flow, and can also calculate the pressure distribution along the interface, he explains. He wants to determine the frictional forces which shape the bottom of the wave, and the causes of the turbulent motion which tears off the oil droplets.

Different kinds of oil are driven into the water in different ways. Professor Milgram studies how breaking waves move droplets of oil into the wave column by filming the interaction in the lab channel. The layer of oil is pushed deep into the water by the wave's force; slow-motion film records in detail the sinister dark dance of oil drops as they break into smaller drops that permeate the waters depth.

How fast do waves move oil? "The nostrum now," says Professor Milgram, "is that the oil moves at 3 per cent of the wind speed. But that's not entirely true. The waves move oil and water; they are made by the wind, and sometimes they move the oil 1 per cent faster than the water." (He has worked out a theory to explain this.)

"The problem of where an oil slick goes is a big one. We'd like to be able to predict where to bring clean-up equipment.

"Accidents like the *Argo Merchant* wreck make congressmen aware," says Professor Milgram. To best equip the country against spillage would cost $200 million to start, plus an additional $10 million a year, he estimates. At least $50 million would be required to refit 80 vessels on the East, West and Gulf coasts to tow barriers for skimming off oil. But these precautions would not be useful in all spills — "there's no such thing as a stereotype oil spill." (His cost estimate includes money for lightweight fenders, barges, better pumping equipment and training of personnel.)

"My personal goal would be to be able to pump up half the oil from half the oil spills," says Professor Milgram. — *M.L.*

NUCLEAR

The Nuclear Cat Is Out of the Bag

A developing country is by definition a growing country, and energy is a crucial ingredient for growth. Pakistan, for example, wants to use 800 to 1,000 kilowatt-hours a year per capita by 2000. Today the figure, for a much smaller population, is 140 kilowatt-hours.

It is conventional wisdom that such a developing country should turn to simple, proven technology — which, in the case of energy, means wood, coal, and oil. But wood is simply too inefficient as an industrial fuel supply; coal and oil are increasingly expensive for nations without indigenous fuel supplies and ample foreign exchange; and oil looks especially risky because it is controlled by a cartel and is the fuel of choice of the world's richest nations.

All these signposts point Pakistan and many other developing nations toward improbably high technology: nuclear power, including, by implication, nuclear fuel reprocessing to recover uranium and plutonium for reuse from spent fuel. Hence general dismay in the Third World when President Gerald R. Ford last fall postponed indefinitely U.S. fuel reprocessing and asked other nations in the nuclear club to join in delaying the advent of the plutonium age.

As Victor Gilinsky, Commissioner of the U.S. Nuclear Regulatory Commission, explained in this magazine early this year (*see "Plutonium, Proliferation, and Policy," February, pp. 58-65*), plutonium is the stuff of nuclear weapons, a tricky substance to handle even without the threat of proliferation in the hands of aggressive nations and unscrupulous blackmailers. But the debate has hardly begun, and now it seems that Mr. Ford's action may have increased rather than decreased the possibility that nuclear power will be transformed from powerful social good to immense social evil.

President Ford's statement implied a vote of "no confidence" in the arrangements which exist for controlling nuclear proliferation through the International Atomic Energy Agency; some Third World nations interpreted it as going back on earlier commitments to provide reprocessing facilities for their spent fuel and some as repudiation of the nonproliferation treaty itself.

Those who argue against Mr. Ford's position do so on two grounds:

— A fuel moratorium which threatens the economic productivity of existing and planned nuclear plants will force Third World nations into the nuclear fuel business; it's a complicated technology, and such plants will represent the most dangerous kind of proliferation. An open policy making fuel available to all from a well managed group of reprocessors operating under safeguards such as those now in place by the I.A.E.A. is vastly to be preferred.

— The absence of nuclear power does not guarantee the absence of proliferation. Indeed, a country that wishes to produce explosives would do so far more easily with a research reactor and pilot reprocessing plant than with the enormous investment of a nuclear power plant and commercial reprocessing facility. "The technological cat is out of the bag, and it cannot be put back," said Sigvard Eklund, Director General of I.A.E.A., in a bicentennial lecture at M.I.T. this spring.

"For the first time in history," said Dr. Eklund, "an international inspection system is in place . . . . The fear of seeing the spread of nuclear explosive technology should not lead to limitations on technological progress." — *J.M.*

Nuclear Wastes: Burial At Sea

About a million years ago, certain upright bipeds were just beginning to do things that would cause us in this modern era to call them human. About a million years from now, high-level radioactive wastes from today's nuclear power plants will be gasping out their last stray particles. A lot can happen in 10,000 centuries.

So when one tries to dispose of these long-lived toxic wastes, the only allowable definition of success must be that "there is almost no likelihood of radionuclides reaching man's environment while they are still radioactive. . . . The waste must be isolated from man for at least a million years," writes G. Ross Heath, Professor of Oceanography at the University of Rhode Island. He and other oceanographers working on E.R.D.A.'s Seabed Emplacement Program have been studying the possibilities of disposing radioactive wastes in the only remaining piece of worthless real estate left — the ocean floor. Their preliminary findings appear in the winter issue of *Oceanus*.

After three years of study, the concensus is that seabed disposal may be possible. At least, they say, nothing was discovered to immediately rule out that option.

They chose to study MPGs, (for mid-plate, mid-gyre), the geologically quiescent central regions of the great tectonic plates which lie at the centers of the slowly circling ocean gyres, or currents. These are the least active areas of the ocean, and they are most likely to remain so for that unimaginable length of time. Compared to the biologically active continental shelves, there is little plant and animal life in the MPGs.

The plan is that the nuclear waste, which the power plant delivers as a solution of radioactive elements in nitric acid, will be fused into a glassy solid. The glass will be sealed in non-corrosive titanium- and zirconium-alloy cannisters, one-by-ten feet. These cannisters will then be buried in the clay-like ooze which covers the ocean floor in the MPG region.

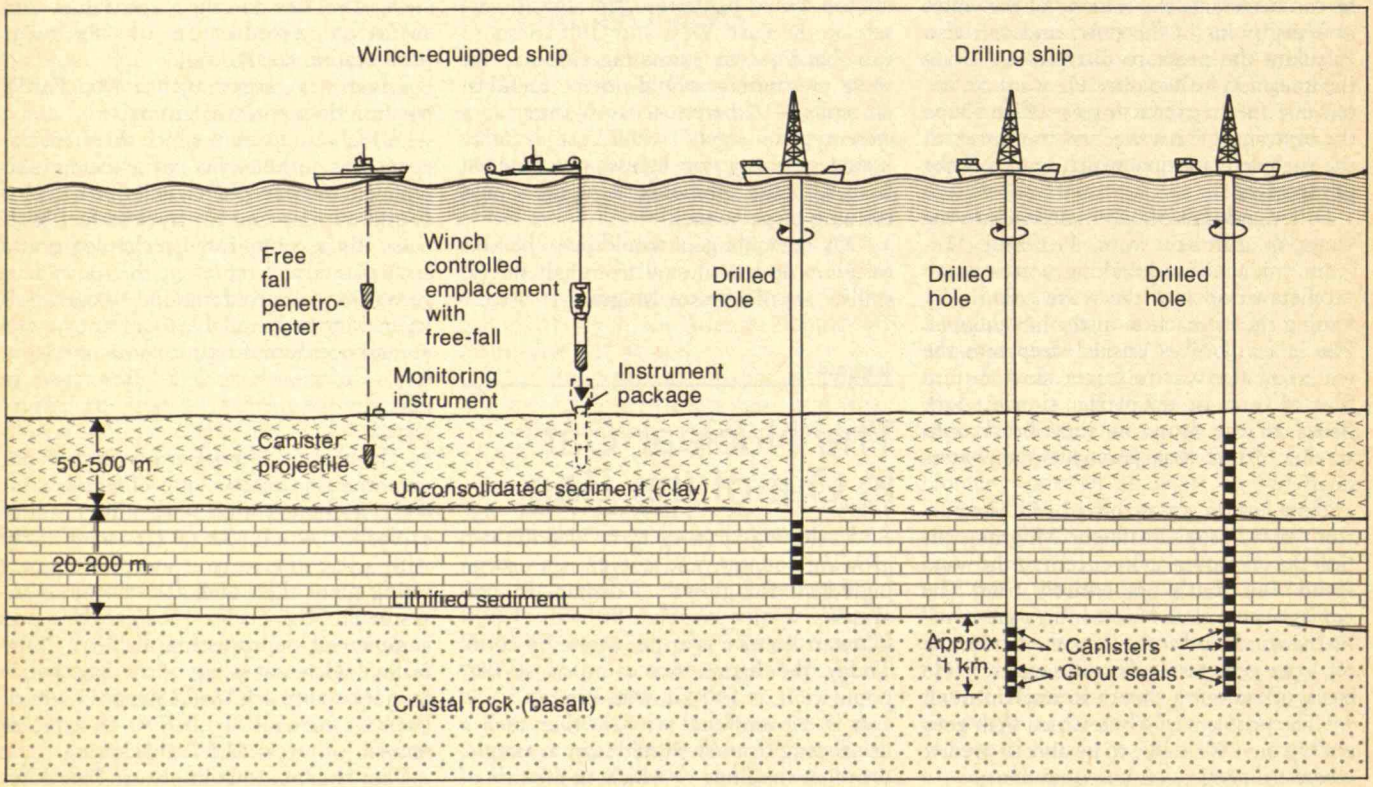
The glass barrier will decompose from internally produced heat within about a thousand years. The alloy casements are expected to last for a few thousand years. Thus it will be up to the silt to protect the wastes for the remaining hundreds of thousands of years. The question now is whether the deep ocean silt is deep enough and sufficiently stable, when disturbed by burial procedures and by the high temperatures created around the radioactive cannisters, to protect the surrounding environment from radioactivity.

Armand J. Silva of the University of Rhode Island, who reported on the properties of the silt, believes the cannisters will be hot enough to cause currents in the surrounding water for several hundred years after burial, but the flow will have the effect of slowly dissipating the heat during the period when the tanks and solids are most likely to be without cracks and small leaks.

Laboratory tests have indicated that undisturbed silt could keep radioactive chlorine within a 100-meter area for the requisite million years, and other tests show travel distances for substances such as radioactive strontium and cesium of 30 meters or less per million years. On the basis of these studies, Dr. Heath writes, "for an undisturbed system, deep-sea clays probably provide a satisfactory barrier to protect man from buried waste."

A previously mapped area, about 600 miles north of Hawaii, was chosen to serve as a prototype MPG. Charles Hollister, a scientist at Woods Hole Oceanographic Institution, reported that currents in that area were very low; the bottom water could move nuclides from one side of the Pacific to the other in between 100 and 1,000 years, but the most serious radiation would by then have disappeared. Dr. Hollister points out that this area has not been chosen as an actual disposal site.

The sediments in the test area are about 30 meters thick and are layered at intervals with ash from volcanic explosions. A core taken from the area shows that these sediments, the first of which were laid over 65 million years ago, have remained undisturbed in spite of glacial eras and other above-water occurrences. — *S.J.N.*



Actual emplacement methods for cannisters of glassified radioactive waste have been suggested. The cannisters could be dropped into the sea from a winch-equipped ship, and force their way to rest 30 meters below the sediment floor. Or, the cannisters could be placed by twos and threes in drilled holes. Least likely is the use of unmanned undersea crawlers to dig burial trenches for the cannisters. (Drawing: *Oceanus*)

How High Is Your Scrabble Score?

Puzzle Corner
by
Allan J. Gottlieb

I have received several comments on possible sexism in this column, all centered on the use of the term, "old maid," which is apparently insulting to women. As you may recall, this was the term on which Ms. Fester originally commented (*see February, p. 67*). My only defense is that "old maid" is not part of my vocabulary, and my first thought when I hear it is of the children's card game. But this excuse is obviously inadequate, since many other people have different impressions and find the term offensive. It will not appear again.

The backlog of regular problems remains in excess of a year and a half. Backlogs of chess, bridge, and speed problems are much less.

Problems

JUN 1 We begin this month with a bridge problem from Russell A. Nahigian:

	♠ Q J 10 9 4 ♥ Q 5 ♦ A J 10 ♣ J 10 3	
♠ K 7 6 3 2 ♥ 6 3 ♦ 3 ♣ Q 9 7 6 2		♠ 8 5 ♥ K J 9 7 ♦ Q 9 8 7 ♣ 8 5 4
	♠ A ♥ A 10 8 4 2 ♦ K 6 5 4 2 ♣ A K	

You are south, the declarer, at a contract of three no-trump. West opens with ♣ 6. How do you play the hand?

JUN 2 James N. Cawse and Zoltan Mester are avid Scrabble fans, and they wanted to know the maximum possible score in a legal match. This seems too hard to me, so I'll settle for the maximum possible score for one player on one turn. Of course, any solution to the original Cawse-Mester problem would also be appreciated.

JUN 3 Joseph Haubrich knows the standard proof that the base angles of an isosceles triangle are equal. One of his geometry books claims this can be done without constructing an angle bisector. Can anyone help him find this proof?

JUN 4 A computer (really, calculator) problem from B. W. Letourneau, who explains that the basis is an early Monroe electronic calculator design, with a four-register stack plus one storage register. In addition to numerical entries and clear and print instructions, there are nine operating "keys" with the following functions:

From this initial condition of the registers:

M D C B A

The "add" instruction yields:

M O D C A + B

The "subtract" instruction yields:

M O D C B − A

The "multiply" instruction yields:

M O D C A · B

The "divide" instruction yields:

M O D C B/A

The "square root" instruction yields:

M D C B $\sqrt{A}$

The "repeat" (or "enter") instruction yields:

M C B A A

The "interchange" instruction yields:

M D C A B

The "recall" instruction yields:

M C B A M

The "store" instruction yields:

M D C B A

These operations are very similar to those of the HP-35 calculator, except that arithmetic operations do not reduplicate D in the top register and there is no "roll" instruction. The problem can just as well be worked on paper without a calculator; it is:

Starting from an initial condition of a "1" in the first register:

0 0 0 0 1,

it is possible to generate any rational number using the above nine operations. The problem is to generate a given number in the minimum number of operations; my favorite is the number 355/113, a close approximation to pi.

JUN 5 Our last problem, from Emmet J. Duffy, could be considered number-theoretic, but I prefer to think of it as auto-mechanic-theoretic:

Six width gauges are permanently mounted on a ring. They can measure any width from 0.001″ to 0.031″ in 0.001″ steps by using individual gauges or by sliding two, three, four, five, or six consecutive gauges together. Find five ways to do this, giving the widths of the gauges and their order on the ring.

Speed Department

JUN SD1 A suburban speed problem to help people mow, posed by none other than R. Robinson Rowe:

Mowing my rectangular lawn, I cut 13 inches on each pass. After two circuits I had cut 16 per cent and after two more circuits 31 per cent of my lawn. How many circuits before I was done?

JUN SD 2 A very interesting economic challenge from Hal Varian: Consider a sealed-bid auction. Each person has a "true value" for the good being auctioned off. But depending on each person's beliefs about what other people's valuations might be, the actual bids of each person will not necessarily be equal to his true value. This auction system does not result in true revelation of preference. The problem is to derive a simple variant of this scheme so that it never pays to lie about your true bid. You may assume no collusion.

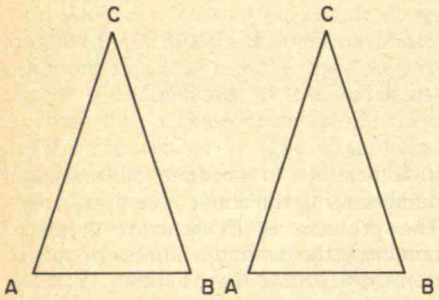
Solutions

This issue will clear up three of the "Never Solved" problems.

Judith Q. Longyear comments that many of her topological friends have been going crazy over NS4. So here is the answer: the singly infinite torus is homeomorphic to the infinite jailcell, whereas the doubly infinite torus is not. For de-

tails, see the problem section after Chapter 1 of Spivak's *Differential Geometry*, Vol. 1.

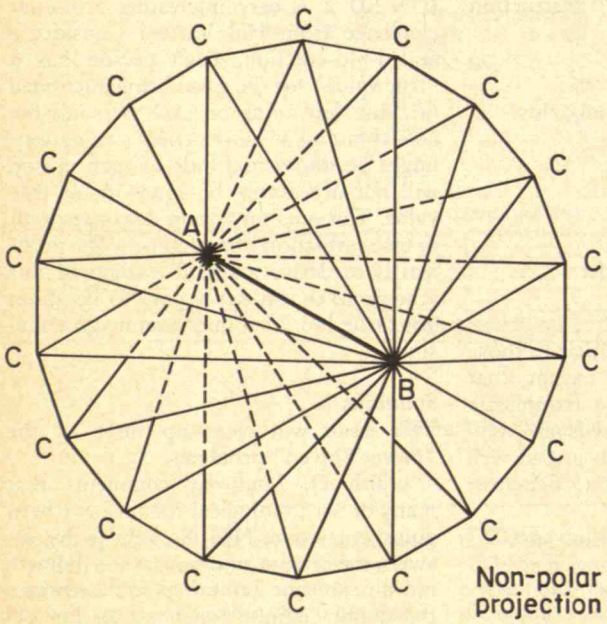
NS 5 If a pair of triangles is not co-polar, the joins of corresponding vertices form a triangle and so do the intersections of corresponding sides. The original pair of triangles has been transformed into a second pair which can be transformed into a third and so on. How does the sequence of pairs of triangles behave?



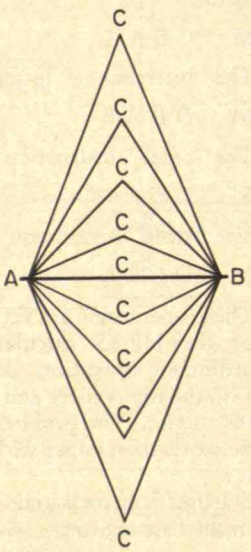
This one has had *me* baffled since it first appeared. I really do not follow the terminology at all, so I present the following, from Benjamin Gray, without claiming to understand it:

The joins of corresponding vertices form a triangle, and so do the intersections of corresponding sides. The joins are to connect by line or lines, to be contiguous or in contact, and to unite or come in contact.

1. Vertice of angle A in contact with angle A; vertice of angle B in contact with angle B; vertice of angle C connected by line to angle C.
2. Intersections of corresponding sides: CB intersects CB, CA intersects CA.
3. Triangles formed by joins and intersections are CCA and CCB.
4. Angles C following the points of the compass are not copolar.
5. The result is shown in projection and end view:



Non-polar projection



End view

NS6 This is the one about the cruise to the Lesser Antilles, with a diagram to be completed. The crew of five were the skipper, first mate Joseph, navigator Peter, deck hand Moses, and cook Able. They all voted for Eisenhower. The total miles shown on the taffrail log was twice the number for the first nine days plus exactly 200 miles. However, we had the log carefully checked and found that for each mile registered we had sailed 6,120 feet, so the distance sailed was slightly greater than that shown on the log. As to the crew, it so happened that if Peter had been 14 years older the skipper would have been twice the average age of his crew. Also if the skipper had been 13 years older his age would have equaled the sum of the ages of the three youngest members of the crew. The dimensions of the boat, sail area, and ages of crew can now be easily ascertained by completing the diagram and using the following clues.

Across

1 Yards sailed in nine days
5 Age of first mate
6 Twice the age of Joseph
7 Miles logged in nine days minus 1 down
11 Square of 4 down minus 2 down
13 Total miles logged
15 Age of Moses
16 Length overall
17 1 down reversed

Down

1 Cube of beam in yards or square of draft in feet
2 Miles logged in nine days
3 Area of mizzen times beam
4 Two times 5 across
8 Length overall times draft
9 Area of mainsail or twice area of mizzen plus sum of digits of 11 across
10 Area of mainsail plus length overall
12 Low water length plus length overall plus draft plus beam
14 Age of Able

Another clue: the problem was concocted some years ago.

This story has a happier ending: many solutions have arrived, as predicted in February. William B. Blake supplied the following derivation:

The solution can be found after solving step one down. The cube of the beam must be the square of the draft, and this must be a two-digit number; 64 is the only number under 100 and greater than 10 which is both cube and square. Step one across can then be found by checking for three-digit numbers which when multiplied by 2,040 (the number of yards in 6,120 feet) gives a six-digit number which begins with 6, and whose second digit is the first digit of the three-digit number. The only numbers which satisfy these conditions are 312 and 636,480. Step six across is then found by multiplying step five by 2. Step seven across is then found by subtracting steps two down and one down. Steps thirteen across, eleven across, and eight down can be found by multiplication and subtraction of previous steps. Then, all of the rest of the steps, except the age of Pete can be found easily by substitution of previously-known facts. The age of Pete can then be found by remembering that the voting age in 1956 (they all voted for Eisenhower) was 21; both 18 and 28 fit the age equations, but 28 is the only age high enough to vote. So Pete must have been 28. Thus, the age of the skipper is (26 + 27 + 28 − 13) or 68.68 also satisfies the first age equation: [(26 + 27 + 28 + 41) + 14]/2, which equals 68, so the solution checks out. Summarizing, then, here are the required numbers:

Ages: Skipper — 68 years; Joseph — 41 years; Peter — 26 years; Moses — 27 years; and Able — 28 years.

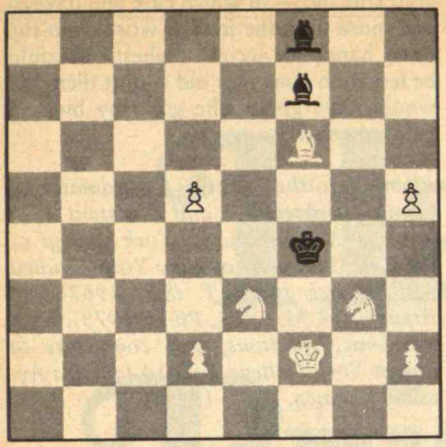
Dimensions: length — 58 feet; draft — 8 feet; beam — 12 feet; area of mainsail — 827 square feet; area of mizzensail — 407 square feet.

Distances: total miles logged — 824; miles logged in nine days — 312; yards sailed in nine days — 636,480.

1 6	2 3	6	3 4	4 8	0
5 4	1	■	6 8	2	■
■	7 2	8 4	8	■	9 8
10 8	■	11 6	4	12 1	2
13 8	14 2	4	■	15 2	7
16 5	8	■	17 4	6	■

Also solved by William A. Bundy, B. Dennis Sustare, Robert Hess, Jim Kempner, Eugene G. Kovach, William J. Butler, Jr., Mr. and Mrs. D. Szper, Edwin Nordstrom, R. Robinson Rowe, Michael Jung, Robert Lutton, Ronald Ort, Oljan Repic, and John F. Chandler.

FEB 1 White to mate in two:



This problem is far less eccentric than previous chess offerings. All solutions were identical: White's first move is P — Q3. If Black replies B x RP, White mates by N x B. Any other Black move is followed by N — K2 (mate).

Solutions received from Howard Ostar, John Schuster, Anthony Coppola, Linsay Faunt, James L. Larsen, Robert Hisiger, Avi Ornstein, Dan Albert, Jim Kempner, William J. Butler, Jr., Ronald Ort, Donald Barnhouse, David M. Johnson, Bruce Stangle, John F. Chandler, Benjamin Rouben, Elliott Roberts, Peter Groot, and Oleg J. Devorn.

FEB 2 The 11 football players of Croam play five-on-a-side matches against each other, the 11th player being referee. One match is played with each possible choice of teams and referee. Can you schedule the 1,386 matches so that each individual team plays its six matches on six different days of the week (Sundays being off limits to football on Croam)?

There were no takers. R. Robinson Rowe thinks it unlikely that such a schedule exists.

FEB 3 Solve:

$$\begin{aligned} x_1 + x_2 + x_3 &= a^2 \\ x_1 + x_2 + x_4 &= b^2 \\ x_1 + x_3 + x_4 &= c^2 \\ x_2 + x_3 + x_4 &= d^2 \end{aligned}$$

where each symbol is an *integer* and the four x's are unique.

The following was submitted by Robert Lutton:

By applying Cramer's Rule or by just suitably combining the equations, the system of equations can be transformed to:

$$3x_1 = a^2 + b^2 + c^2 - 2d^2$$

$$3x_2 = a^2 + b^2 - 2c^2 + d^2$$

$$3x_3 = a^2 - 2b^2 + c^2 + d^2$$

$$3x_4 = -2a^2 + b^2 + c^2 + d^2$$

The only way that each of these equations can apply for integer values of all symbols is for a^2, b^2, c^2, and d^2 each to be divisible by 3. However, trying it for a = 3, b = 6, c = 9, and d = 12 gives a negative value for x_1, which was disallowed. With a few trials it can be found that with a = 24, b = 27, c = 30, and d = 33 you get $x_1 = 9$, $x_2 = 198$, $x_3 = 369$, and $x_4 = 522$. This is just the set of smallest values; there are an infinite number of solutions. For instance, a = 300, b = 303, c = 306, and d = 309 gives $x_1 = 28161$, $x_2 = 30006$, $x_3 = 31833$, and $x_4 = 33642$.

Also solved by Peter Groot, John F. Chandler, Mr. and Mrs. D. Szper, Naomi Markovitz, William J. Butler, Jr., Avi Ornstein, Harry Zaremba, Winslow H. Hartford, Emmet J. Duffey, W. Allen Smith, Frank Carbin, John E. Prussing, Harvey M. Elentuck, Timothy Maloney, R. Robinson Rowe, and the proposer.

FEB 4 For all N > 0, find N positive integers (not necessarily distinct) whose sum and product are equal.

This one was so easy even I solved it: For N = 1, use 1 = 1. For N > 1, use

$$\underbrace{1 + 1 + \ldots + 1}_{N-2} + 2 + N = \underbrace{1 \cdot 1 \cdot \ldots \cdot 1}_{N-2} \cdot 2 \cdot N.$$

The proposer, Mickey Haney, found an additional solution for odd N > 1:

$$\underbrace{1 + \ldots + 1}_{N-2} + 3 + (N+1)/2 = \underbrace{1 \cdot 1 \cdot \ldots \cdot 1}_{N-2} \cdot 3 \cdot (N+1)/2.$$

Also solved by R. Robinson Rowe, Ronald Ort, Benjamin Rouben, M. Kaufman, Naomi Markovitz, George Flynn, Harvey M. Elentuck, John E. Prussing, W. Allen Smith, Winslow H. Hartford, Harry Zaremba, Avi Ornstein, William J. Butler, Jr., Mr. and Mrs. D. Szper, John F. Chandler, and Peter Groot.

FEB 5 Construct a 4 × 4 × 4 magic cube (equal sums along horizontals, verticals, in-outs, and diagonals) consisting of 64 distinct numbers.

Only the proposer, Robert Mills, could solve this problem; and his answer is that such a magic cube is impossible:

Use an additive constant so that the sum for each row, column, etc., is zero.

Using Cartesian coordinates to label elements, we get

$$0 = 0 - 0 - 0 + 0 + 0 =$$

$$\begin{aligned} &(111+212+313+414) \\ &-(111+222+333+444) \\ &-(112+212+312+412) \\ &+(112+222+332+442) \\ &-(113+213+313+413) \\ &+(113+223+333+443) \\ &+(114+213+312+411) \\ &-(114+223+332+441) \\ &+(411+412+413+414) \\ &-(441+442+443+444) \end{aligned}$$

$$= 2\,(411+414-441-444)$$

So $(411+414-441-444) = 0$.

Similarly,

$$(411-414+441-444) = 0,$$

so that 411 = 444, contrary to the requirement.

Proposer's Solutions to Speed Problems

JUN SD1 In modules of 26 inches, the uncut area can be expressed as

$$A = x(x + c),$$

where c is the constant excess of length over width. This is a quadratic, for which the second difference will be constant. Since the first two first differences were proportional to 16 and 15, the next six will be proportional to 14, 13, 12, 11, 10, and 9, for a total of 100 per cent. At two circuits each, that meant 12 more circuits. (It wasn't asked, but if you must know, the lawn is 54′2″ by 17′4″.)

JUN SD2 The good is sold to the highest bidder, but he has only to pay the second-highest bid. In this auction, it never pays to lie about your true bid! First, you would never want to bid less than your true bid, since increasing your bid increases your chances of getting the good without affecting what you have to pay. Consider what can happen if you bid *more* than your true value. Then the

Classified

second-highest bid could be more than your true bid — in which case you have to pay more than the item is worth. On the other hand, the second highest bid could be less than your true bid — but then you would have gotten the good by bidding your true bid.

Allan J. Gottlieb, who is Coordinator of Computer Activities and Assistant Professor of Mathematics at York College of the City University of New York, studied mathematics at M.I.T. (S.B. 1967) and Brandeis (A.M. 1968, Ph.D. 1973). Send problems, solutions, and comments to him at York College, 150-14 Jamaica Avenue, Jamaica, N.Y., 11451.

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Letters

Continued from p. 2

and public transportation most effective, are the two modes comparable in passenger miles. Space heating in Sweden is far different than in Germany because all rooms in Sweden are heated and living space per capita is nearly as great as in the U.S. Differences in use per unit of climate arise from significantly greater levels of insulation and weatherization in Sweden compared to the U.S., and not from the number of apartments in the stock or the number of rooms that are heated. We note in our study that economic factors — the price of energy — play a big role in stimulating Swedes to use energy more efficiently than Americans do for similar activities. The economic stimulus towards energy efficiency probably outweighs "fundamental differences in attitudes" you mention, though it is accurate to say that energy use in Sweden appears to approach its own optimal level of use, measured economically, to a greater extent than in the U.S. We also note that you described energy use in these countries in terms of megawatts per $1,000 of GNP, when the correct units were megawatt-hours per $1,000.

Lee Schipper
Allan J. Lichtenberg
Berkeley, Calif.

Dr. Schipper is an energy specialist for the Energy and Resources Program of the University of California at Berkeley. Dr. Lichtenberg is Chairman of the program's Energy and Resources Group. — Ed.

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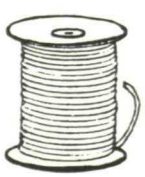
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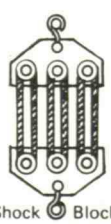
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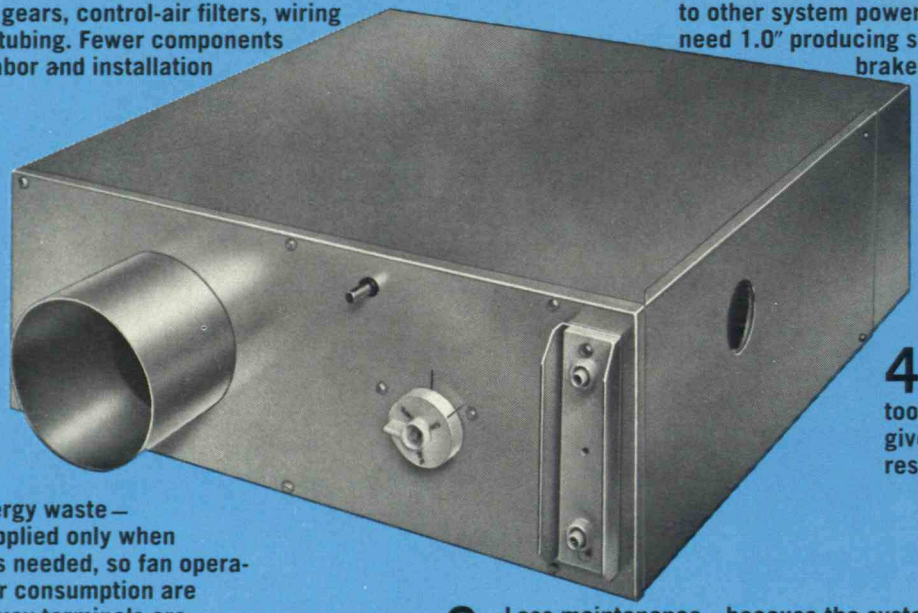

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